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CONTENTS

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Rent Seeking Behavior, Political Parties and Universities

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Abstract

In public universities in Bangladesh, student political activity takes place while in private universities these activities are banned. Political parties very often sponsor student political activity and in reality most of the major parties have their own student wings in the public universities (Mukta, 2009). It is also evident that once a political party is in power, it recruits from these student bodies, at times violating the recruitment rules and regulation processes in the Public Service Commission (PSC).

This feature of the education system implies that public education and private education are differentiated goods and both political parties and students are engaging in rent seeking behavior. To capture this behavior, we develop a model as a three stage game: Inter alia, we show that in an economy with a higher probability of getting jobs, a rent seeking ruling political party wants students of public universities to be less involved in politics and vice versa. Finally, under some conditions, involvement in campus politics enhances aggregate expected income level of all employed graduate students.

Keywords: rent seeking, differentiated goods, game theory, political parties

JEL: C72,H41,I21,L1

1. INTRODUCTION

In Bangladesh there are a small number of public universities with highly subsidised tuition fees and a large number of private universities with higher tuition fees. In the public universities, student political activity takes place while in the private universities these activities are banned. Political parties very often sponsor the student political activity and in reality most of the major parties have their own student wings in the public universities (Mukta, 2009). It is also evident that once a political party is in power, it recruits from these student bodies, at times violating the recruitment rules and regulation processes in the Public Service Commission (PSC).[1]

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1 Tusher (2005) quotes some pertinent statistics on the profile of government appointees and their political activism as members of university political clubs. Mukta (2009) also states that "After the 9th parliamentary election, anarchy in the educational institution seems to be an everyday affair" and that "The universities are turning into a battle field with mediaeval barbarism to kill or cause grievous hurt to fellow students" (page1).

This feature of the Bangladesh education system implies that public education and private education are differentiated goods and both democratic parties and students are engaging in rent seeking behavior.[2] To capture this behavior, we develop a model as a three stage game: In stage 1, a democratic ruling party's decision to become involved actively in political activities on a public university campus is modeled; In stage 2, the ruling party decides how much subsidy it should provide to the public university and finally stage 3: both public and private universities compete on price in the higher education market. Inter alia, we show that in an economy with the higher probability of getting jobs, a rent seeking ruling political party wants students of public universities to be less involved in politics and vice versa. Finally, under some conditions, involvement in campus politics enhances aggregate expected income level of all employed graduate students. Section 2 sets out the model while section 3 sets out the main results.

2. THE MODEL

We assume that an individual student requires minimum effort β to graduate from any university and as a successful graduate student, he will obtain benefit $\lambda > 0$. For simplicity and without loss of generality we normalize β to zero. Student politics requires effort level r such that $r \in [0,1]$.[3] There is an opportunity cost $r\lambda$ for providing effort r in student politics. Such a cost is imposed on each and every student who has been admitted into that public university.[4] Therefore, a student who has been admitted into public university will obtain net benefit $\lambda - r\lambda = (1-r)\lambda$. This implies that net benefit is decreasing as r increases.

The probability of getting a job as a fresh graduate student is m and the probability of getting a job for an individual student of a public university is $m + r$. The crucial aspect of this paper is that it assumes that all students of a public university are opportunistic; hence they join the student wing of a political party. Therefore, anyone who graduates from the public university will enjoy the probability of getting job $(m + r)$ of a getting a job. We assume that both m and r are independent such that $r \in [0,1]$ and $0 \leq (m+r) \leq 1$. Student politics is

2 As stated by Congleton, Hillman and Konrad (2008) : "Incentives for rent seeking are present whenever decisions of others influence personal outcomes or more broadly when resources can be used to affect distributional outcomes" (page 1).

3 Such student politics takes place in the public universities and is heavily supported by the mainstream political parties.

4 For example, in Bangladesh, campus violence caused by students' politics can close the university for long periods. This causes problems for all the students of that university by delaying their graduation (also known as *session jam*).

banned in the private university, hence, $r = 0$ in the private university. A successful graduate student of a private university will get a benefit λ and her probability of getting job in the labour market is *m*.

In the public university, not all of the students are admitted because of limited places. Assume that, ϕ is the probability of getting admission into a public university such that $\phi \in [0,1]$. In addition, a public university's tuition fee, denoted by $\hat{T}_1$, is highly subsidized. Given the subsidy amount s > 0 then $\hat{T}_1 = T_1 - S$ (To stands for tuition fee of a public university). Denote T_2 as the tuition fee of a non-subsidized private university. Furthermore, an individual student *i* is indexed by ϕ_1 represents the *i*th student's preference for the public or private university. Therefore, the following defines the expected utility level from each university.[5] Note that that there are two players i.e. $j = \{1, 2\}$, where player 2 are the public and private university respectively and both are competing in the higher education market.

$$U_{i,j} = \begin{cases} \varphi(1-r)\lambda\theta_i - T_1 + s & \text{(if she goes to public university),} \\ \lambda\theta_i - T_2 & \text{(if she goes to private university).} \end{cases} \quad \ldots\ldots\ldots\ldots (1)$$

Equation (1) implies that, in the presence of rent seeking behaviour, limited places and subsidies, higher education becomes a horizontally differentiated good.[6] The fact is that any change in the values of either ϕ or *r* or *s* may make some students better (or worse) off.

From condition (1) the demand for private and public education can be derived. The condition for an individual student who prefers a private university to a public university or at least will be indifferent between the two will be as follows:

$$U_{i,2} \geq U_{i,1} \Rightarrow \theta_i \geq \frac{T_2 - T_1 + s}{\mathcal{L}} \equiv \theta^* \quad \ldots\ldots\ldots\ldots (2)$$

Here, $\mathcal{L} = \lambda[1 - \phi(1-r)]$ Following from equation (2), there exists a θ^* such that for any $\theta_i \geq \theta^*$ the θ_i th student will prefer a private university. We normalize the total number of students, say *N* to 1. Since ϕ is uniformly distributed over an interval [0, 1], we obtain the following demand for each university:

---

5 We assume that probability of getting admission into the private university is 1 as long as an individual student can afford the tuition fee T_2.

6 See Shy (1995), page 310.

$$D_1(T_1,T_2)=\int_0^{\theta^*} dF(\theta)=\theta^*=\frac{T_2-T_1+s}{\mathcal{L}}$$

$$D_2(T_1,T_2)=\int_{\theta^*}^{1} dF(\theta)=1-\theta^*=1-\frac{T_2-T_1+s}{\mathcal{L}} \quad \text{..... (3)}$$

Given equation (3), an individual university j will choose its own T_j to maximize Π_j which is defined as follows:

$$\max_{T_j} \Pi_j = T_j D_j(T_1,T_2) \quad \text{..... (4)}$$

2.1 Structure of the Game

In this game, we assume that ruling party is also a rent seeker. This ruling party supports its student wing on the campus, which in turn may help a ruling party to use the student party for its own benefit.[7] Given its preference (which is defined later), a ruling party has to choose the level of student activity it is willing to support. We denote r_s as the level of student activity supported by a ruling party. Using this set up, we have constructed three-stage game, which is as follows:

Stage 1: Ruling political party has to choose r_s to maximize its utility level.

Stage 2: Ruling party has to choose s i.e. level of subsidy to maximize Π_1^*

Stage 3: Each university j is competing in higher education market, hence, it chooses T_j^* to maximize its Π_j^*

To solve this game we use backward induction. The following section summarizes the final outcomes of our game.

2.2 Reaction Functions and Results

The reaction functions are derived with the help of equations (3) and (4), which is as follows:

$$T_1(T_2)=\frac{1}{2}[s+T_2]$$

$$T_2(T_1)=\frac{1}{2}[\mathcal{L}-s+T_1] \quad \text{..... (5)}$$

7 For example, in a developing democratic country like Bangladesh, very often the mainstream parties join with their student wings in demonstrating, which sometimes leads to violence (Mukta, 2009).

Solving equation (5), we obtain the following results of Bertrand Nash equilibrium:

$$T_1^* = \frac{[s+\mathcal{L}]}{3};\ T_2^* = \frac{[2\mathcal{L}-s]}{3}$$
$$\Pi_1^* = \frac{[s+\mathcal{L}]^2}{9\mathcal{L}};\ \Pi_2^* = \frac{[2\mathcal{L}-s]^2}{9\mathcal{L}} \quad \text{..... (6)}$$
$$\theta^* = \frac{T_2^* - T_1^* + s}{\mathcal{L}} = \frac{1}{3}\left(1+\frac{s}{\mathcal{L}}\right)$$

From equation (6) we develop the following Lemma:

Lemma 1

An increase in s will increase T_1^* but decrease T_2^* at Nash Equilibrium.

Proof: The proof follows from equation (6).

The intuition of Lemma 1 is that an increase in s will increase the demand for public university education since $\frac{\partial \theta^*}{\partial s} = \frac{1}{\mathcal{L}} > 0$ from equation (6) which will lead to an increase in the tuition fee T_1^* of the public university. However, an increase in s will reduce the demand for private university education, therefore, the only way a private university will be competitive is to reduce its own tuition fee T_2^*.

Lemma 1 implies that the level of subsidy s plays a crucial role in the higher education market. This is needed to solve the second stage of our game where a ruling party determines the level of subsidy s. In so doing, we assume that the subsidy is costly. The cost of a subsidy is denoted as $C(s)$ and without loss of generality we also assume it is convex in s i.e. $C'(s) > 0$ and $C''(s) > 0$. To obtain a closed formed solution and tractability of our model, we assume that $C(s) = s^2$. Furthermore, a rent seeking ruling party wants to maximize Π_1^* in choosing s. Indeed, it is in their best interest to do this as any political activity is banned in the private university. Therefore, a ruling party will maximize the following objective function:

$$\max_s \mathcal{W} = \Pi_1^* - C(s) = \frac{[s+\mathcal{L}]^2}{9\mathcal{L}} - s^2$$
$$\Rightarrow s^* = \frac{\mathcal{L}}{9\mathcal{L}-1} = \frac{1}{9-\frac{1}{\mathcal{L}}} = \frac{1}{9-\frac{1}{\lambda[1-\phi(1-r)]}} \quad \text{..... (7)}$$

For feasibility, we need $s^* > 0$, which is always true because $\mathcal{L} = \lambda[1-\phi(1-r)] > 0$ since $\phi \in [0,1)$ by assumption. Furthermore, to satisfy the second order condition i.e. $\frac{\partial^2 \mathcal{W}}{\partial s^2} < 0$, we need $\frac{1}{\mathcal{L}} < 9 \Rightarrow \frac{1}{\lambda[1-\phi(1-r)]} < 9$

Using equation (7) we have the following proposition:

Proposition 1

A. An optimal level of subsidy s^* is decreasing in r.

B. An optimal level of subsidy s^* is increasing in ϕ.

C. An optimal level of subsidy s^* is decreasing in λ.

Proof: By taking derivative of s^* with respect to r, ϕ and λ in equation (7), we obtain:

$$\frac{\partial s^*}{\partial r} = -[\phi]\left(9 - \frac{1}{\lambda[1-\phi(1-r)]}\right)^{-2} \lambda^{-1}[1-\phi(1-r)]^{-2} < 0$$

$$\frac{\partial s^*}{\partial \phi} = [1-r]\left(9 - \frac{1}{\lambda[1-\phi(1-r)]}\right)^{-2} \lambda^{-1}[1-\phi(1-r)]^{-2} > 0$$

$$\frac{\partial s^*}{\partial \lambda} = -\left(9 - \frac{1}{\lambda[1-\phi(1-r)]}\right)^{-2} \lambda^{-2}[1-\phi(1-r)]^{-1} < 0$$

Proposition 1 (A) implies that an increase in r will reduce the optimal subsidy level. Here, r is the effort level of a student reengaged in campus politics. The intuition is that in the public university where student politics are pro-active, the demand for public university education will go down (i.e. the demand $D_1(T_1, T_2)$ falls, from equation (3), hence the tuition fee T_1^* falls (from equation (6). In this scenario, since the tuition fee is low, a rent seeking ruling party (government) will reduce the optimal level of subsidy s^*.

Similarly, when the probability of getting admission into public university ϕ has increased, it will raise the demand for public university education θ^* which will raise the tuition fee T_1^*. Therefore, the government has to increase the optimal

level of subsidy s^*, which explains Proposition 1(B). On the other hand, an increased benefit λ will reduce the demand for public university; hence the tuition fee for the same university will fall. Since the tuition fee is falling, government will lower the optimal level of subsidy. Note, that an increase in λ will increase the demand for private university education as the student politics are banned in the private university. This explains Proposition 1(C).

2.3 Preferences of Rent Seeking Ruling Parties

This section explains the preferences of a rent seeking ruling party, which is needed to solve the last stage of our game where a ruling party will choose the optimal level *r*.

An individual student who graduates successfully will realize the value of λ if she gets employed.[8] Since the probability of getting a job is *m*, the expected benefit for a graduate student from getting employment is $m\lambda$, which is equal to her expected income, by assumption.

Let us first calculate the aggregate level of expected income Y^e earned by the successful graduate students when *r* is set to zero (i.e. no student politics takes place on the campus of any university). The total number of successful students who are graduating from the public university is μ_1 and the total number of students who are graduating from the private university is μ_2. Therefore, the expected aggregate income level will be as follows:[9]

$$Y^e = \phi m\lambda\mu_1 + (1-\phi)m\lambda\mu_2 \quad \text{..... (8)}$$

Here, ϕ is the probability of getting admission into the public university.

The expected aggregate income level Y_r^e when $r > 0$ and $N = 1$ will be as follows:

$$Y_r^e = \phi(m+r)(1-r)\lambda\mu_1 + (1-\phi)m\lambda\mu_2 \quad \text{..... (9)}$$

In equation (9), the second term on the right hand side (RHS) is exactly the same as the second term on the RHS of equation (8). The only difference is the first term on the RHS of equation (9). The intuition is that public university

8 The conventional method of calculating Marshallian surplus will not work in this case as not all of the graduate students will be employed.

9 We assume that there is no borrowing and saving and there are surplus graduate students. Furthermore, unemployed graduate students earn zero income and have to rely on family or other support.

student can participate in student politics, which may increase the probability of getting employment (since $(m+r)>m$) in a government organization. However, participating in student politics has an opportunity cost captured by $(1-r)\lambda$. A comparison of these two equations (8}) and (9), eventually determines the loss of expected aggregate income when $r > 0$, and is calculated as follows:

$$\Delta Y^e = Y^e - Y_r^e = \lambda\phi\mu_1[r^2 + rm - r] \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

In a democratic country, a rent seeking ruling party does care about the loss of aggregate expected income (because of student politics) as too much loss of expected aggregate income can lose them the elections. Therefore, a rent seeking ruling party will set set r in such away that it will minimize ΔY^e. The following provides the objective function of the ruling party:

$$\min_r \Delta Y^e = \lambda\phi\mu_1[r^2 + rm - r]$$

$$\Rightarrow r^* = \frac{1}{2}(1-m) \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

From equation (11) we develop the following proposition:

Proposition 2

A rent seeking ruling party's optimal r^* depends on m such that a decrease in m will increase r^* and vice versa.

Proof: The proof follows from equation (11).

Proposition 2 implies that in an economy where the probability of getting employment m is very high, a ruling party has an incentive to cut back its involvement in campus student politics, hence, a lower r^* is expected. The reason is that, in this scenario, a ruling party's heavy involvement in student politics may cause a large loss in expected aggregate income; hence they may lose the elections. The opposite will be true for an economy where the probability of getting employment is very low.

By placing the value of optimal r^* in equations (6) and (7), one can calculate the optimal value of T_1^* and T_2^*. With the help of equations (6), (7) and Proposition 1, one can show that $\frac{\partial r^*}{\partial m} < 0, \frac{\partial s^*}{\partial r^*} < 0$ and $\frac{\partial \mathcal{L}}{\partial r^*} > 0$. Therefore, $\frac{\partial T_1^*}{\partial m} = \frac{1}{3}\frac{\partial r^*}{\partial m}\left(\frac{\partial s^*}{\partial r^*} + \frac{\partial \mathcal{L}}{\partial r^*}\right) < 0$ if $\left|\frac{\partial \mathcal{L}}{\partial r^*}\right| > \left|\frac{\partial s^*}{\partial r^*}\right|$ which will be true given our feasibility condition $\frac{1}{\mathcal{L}} < 9$; and $\frac{\partial T_2^*}{\partial m} = \frac{1}{3}\frac{\partial r^*}{\partial m}\left(2\frac{\partial \mathcal{L}}{\partial r^*} - \frac{\partial s^*}{\partial r^*}\right) < 0$

Figure 1 illustrates the optimal T_1^* and T_2^* plotted on m, where we assume the following parameters' values: $\lambda = 1$ and $\phi = \frac{1}{2}$.

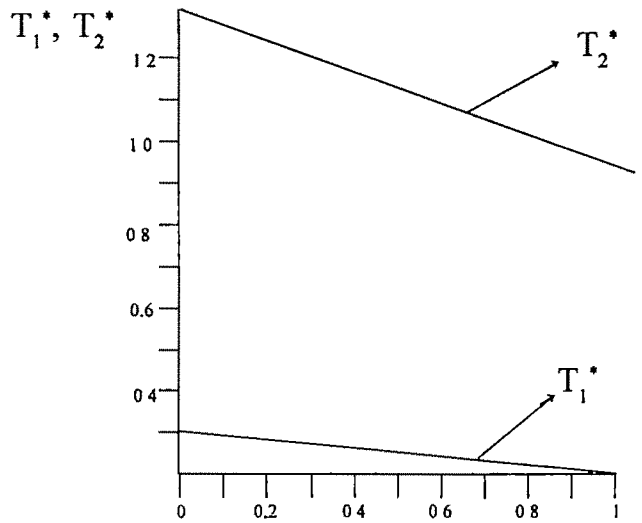

Figure 1: Optimal Values of T_1^* and T_2^*

Both T_1^* and T_2^* decrease as the probability of getting employment m increases. The intuition is that as m increases, r^* will go down which will increase the optimal subsidy level s^* (from Proposition 1). Therefore, the tuition fee T_1^* will decrease at equilibrium. Since T_1^* is falling, a private university will retain its competitive position only by lowering its tuition fee T_2^* at equilibrium.

3. IS INVOLVEMENT OF STUDENTS IN CAMPUS POLITICS IN PUBLIC UNIVERSITY HARMFUL?

This section examines whether the campus politics in public university is harmful to an economy. In order to analyse this, we need to compare equations (8) and (9) i.e. two aggregate expected level of incomes when $\phi = \frac{1}{2}$, $m = \frac{1}{2}$, $\mu_1 = \frac{1}{2}$, $\mu_2 = \frac{1}{2}$ and normalizing $\lambda = 1$ in order to plot those two equations in the

following Figure 2:

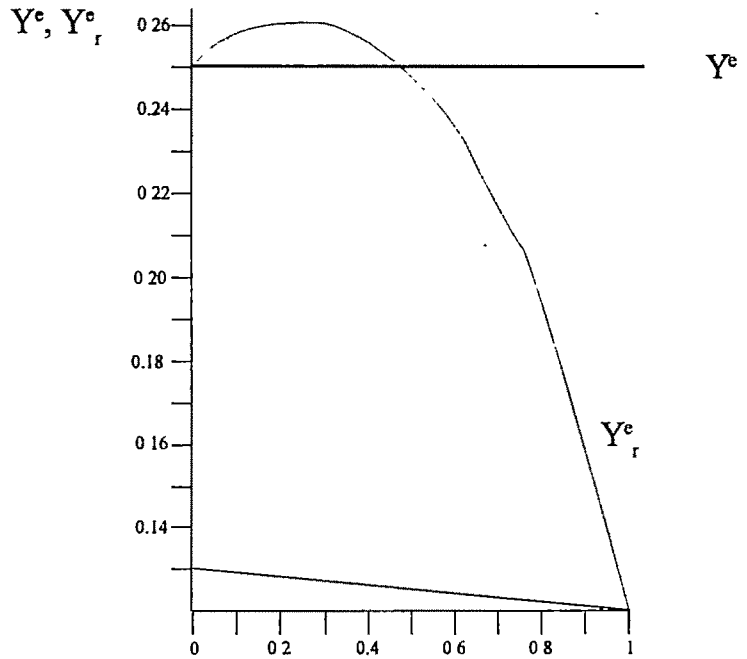

Figure 2: The Expected Aggregate Income Levels and Involvement in Campus Politics *r*.

Figure 2 illustrates that, for any given λ, ϕ, μ_1 and μ_2, involvement in campus politics (i.e. $r > 0$) increases the expected aggregate level of income as the condition $Y_r^e \geq Y^e$ holds for some initial lower values of r. However, when r increases sufficiently high the reverse is true i.e $Y_r^e < Y^e$. This is not surprising as equation (10) captures this. Since ΔY^e is a U - shaped curve with respect to r confirming that at least for some values of r, the following will be true $Y_r^e \geq Y^e$ Therefore, any r that is minimizing the loss ΔY^e implies that it maximizes the aggregate expected level of income Y_r^e. This observation leads to the following proposition:

Proposition 3

For any given value of $\lambda > 0$, $\phi > 0$ and $\mu_1 > 0$, $\mu_2 > 0$ and $m \in [0,1)$ there exists an r^* such that $r^* = \frac{1}{2}(1-m)$ which maximizes the aggregate expected income level.

Proof: The proof follows from equations (10) and (11) and the above observation.

The implication of Proposition 3 is that, in the presence of high unemployment (i.e. lower value of m), any involvement of a ruling party in campus politics increases the expected aggregate level of income; therefore, such involvement is not necessarily bad. However, the same involvement in campus politics reduces the expected aggregate level of income if the unemployment rate is very low (i.e. higher value of m). Perhaps this may provide an explanation as to why there exists pro-active student campus politics in developing and developed economies where unemployment rate is very high and not as active student politics in countries where the unemployment rate is relatively low.

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Equity Control of Multinational Firms: Effects on Income Distribution and Wage Inequality in Host Countries

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Abstract
This paper examines the effects of the equity control of multinational firms on income distribution and wage inequality in a model with skilled and unskilled labor. A large number of recipient (host) countries are developing countries characterized by scarce capital and wage inequality. The results of the study indicate that a restriction on multinational investment may raise the unskilled wage rate and lower the rental of domestic capital while it lowers the skilled wage rate if the multinational sector is strongly capital intensive. Thus, the equity control policy may improve the wage inequality. Furthermore, the increase in labor forth may decrease the wage gap if MNF sector is strongly capital intensive and/or equity control is very stringent.
JEL Classification: F16, F23, O18
Keywords: Multinational firms, Equity control, Income distribution, Wage inequality
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1. INTRODUCTION

Many developing countries suffer from the scarcity of capital and attempt to attract foreign capital from developed countries that show interest in the host country—more specifically, its market, resources, cheap labor, and so on. Inviting multinational firms (henceforth MNFs) is a typical approach by host countries to effectively introduce foreign capital into its economy. However, the operation of MNFs in numerous developing (host) countries may affect various aspects of the social and economic conditions in these countries. While certain developing economies have indeed benefited substantially from multinational expertise and investment, MNFs may have detrimental effects on employment, income distribution, and even national welfare in others. In this sense, foreign direct investment (FDI) through MNFs is viewed "at best, as an instrument of uncertain value in the development process and, at worst, as a contemporary form of neocolonialism" (Hill and Mendez, 1992, p.53).

This paper examines the effects of the equity control of MNFs on income

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distribution and wage inequality in the host countries by examining the difference between skilled and unskilled labor in the economy. Hill and Mendez (1992) discuss the effect of equity control on employment in an economy with minimum wage legislation. They assume that a minimum wage rate is fixed institutionally in both local and multinational sectors. Their analysis was followed by Beladi and Yabuuchi (2009) who reexamined the effect of equity control on employment and welfare under the dual economy setup. They argued that a large number of recipient (host) countries are developing countries with dual economies, thus implying the coexistence of two separate economic systems that develop at different rates.[1] In a series of papers, Chao and Yu examined various aspects of equity control. Chao and Yu (1996) examined the welfare effect of domestic equity controls in conjunction with export share requirements, and Chao and Yu (2000) explored the same issue in the presence of alternative types of trade restrictions and varying degrees of capital mobility. Chao and Yu (2006) examines the effect of partial privatization or foreign competition on optimum tariffs. Recently, Chao and Yu (2007) examined the effects of trade liberalization on firm ownership and the environment in a small open economy. In a related study, Beladi and Chao (2006) considered the employment and welfare effects of mixed ownership via partial privatization of state-owned enterprises in a developing economy.

However, no study examines the effects of equity control on income distribution and wage inequality in the host country. To address this research gap, this paper examines the differences between skilled and unskilled labor by specially focusing on the change in wage inequality between the two. It then investigates the implication of these differences on the changes in factor prices. The wage inequality, in addition to unemployment and welfare, is an important issue in many developing countries. Therefore, our analysis has an important policy implication for many developing countries that are aiming to introduce foreign capital in their economy by effectively restricting the amount through the equity control policy. This paper illustrates that a restriction on multinational investments may lower the inflow of foreign capital and, in turn, increases the total capital employment in the multinational sector. Furthermore, the restriction on multinational investment raises the unskilled wage rate and the rental of domestic capital while it lowers the skilled wage rate if the multinational sector is strongly capital intensive. Thus, the policy may improve wage inequality. This paper will provide a theoretical background for the establishment of MNFs in developing countries. It is also shown that the increase in labor forth may decrease

1 A notable example of this type of economy is China. It has a relatively developed urban sector and less-developed rural sector; moreover, it is witnessing extensive rural-urban migration in the face of urban unemployment. On the discussions of various aspects of dual economy, see, for example, Harris and Todaro (1970), Bhagwati and Srinivasan (1974), Khan (1982), Neary (1991), Beladi and Marjit (1996), Yabuuchi (1993), Gupta (1995), Basu (2000), and Marjit and Beladi (2003).

the wage gap if MNF sector is strongly capital intensive and/or equity control is very stringent.

The remainder of the paper is organized as follows. Section 2 presents the model of the paper and assumptions. Section 3 examines the relationship between equity control and income distribution, and the effects of equity control on wage inequality in the host country. The effects of labor growth on the wage inequality are discussed in Section 4. Section 5 presents the concluding remarks.

2. THE MODEL AND ASSUMPTIONS

Following Hill and Mendez (1992), this paper considers a small open economy that comprises two sectors—the multinational sector, X, and local sector, Y. Sector X and sector Y comprise MNFs and domestic firms, respectively. The production of a local good requires unskilled labor and local capital. MNFs utilize skilled labor, unskilled labor, foreign capital, and domestic capital. Skilled labor is used only in sector X. It is assumed that MNFs produce a manufacturing good, while the local sector produces an agricultural good. Thus, the production functions of the manufacturing sector (i.e., MNFs), X, and agricultural (local) sector, Y, are given as follows:

$$X = F^X(L_X, K_X, H) \quad \text{..... (1)}$$

and

$$Y = F^Y(L_Y, K_Y) \quad \text{..... (2)}$$

where K_j, L_j, and H represent employment of capital, unskilled labor, and skilled labor, respectively, in the i-th sector ($i = X, Y$). The production functions are assumed to be linearly homogeneous and concave, and they satisfy the following properties:

$$F_j^i > 0,\ F_{jj}^i < 0,\ F_{jk}^i > 0,\ F_{LL}^i F_{KK}^i - (F_{KL}^i)^2 > 0 \quad (j,k = L,K,H;\ j \neq k) \quad \text{.... (3a)}$$

and

$$F_j^Y > 0,\ F_{jj}^Y < 0,\ F_{jk}^Y > 0,\ F_{LL}^Y F_{KK}^Y - (F_{KL}^Y)^2 = 0 \quad \text{..... (3b)}$$

where F_j^i is the marginal product of the j-th factor in sector i ($i = X$ and Y), F_{jj}^i is the change in the marginal product of the j-th factor with respect to its own factor, and F_{jk}^i is the change in the marginal product of the j-th factor with respect to the k-th input $(j \neq k)$.

This paper focuses on the effects of the equity control of MNFs on income distribution and wage differential in the host country. It is assumed that the agricultural good (X) is exported and is the numeraire, so that its price equals unity and it is the base good. The manufacturing good (Y), on the other hand, is an importable good with world price p^* but whose domestic price p is increased because of an ad valorem tariff t; that is, $p=(1+t)p^*$

The labor market equilibrium can be expressed as

$$w=F_L^Y(L_Y,K_Y)=pF_L^X(L_X,K_X,H) \quad \text{..... (4)}$$

and $$w_s=pF_H^X(L_X,K_X,H) \quad \text{..... (5)}$$

where w and w_s are the wage rates of unskilled labor and skilled labor, respectively.

Foreign capital employed in sector X is internationally mobile but intersectorally immobile, which implies that foreign capital cannot be employed in domestic sectors. The government imposes this equity restriction on sector X in order to protect domestic firms. Let us assume that MNFs are required to employ a certain percentage of domestic capital in sector X. Let β represent the domestic capital requirement rate. Thus, the total capital employed in sector X, K_X, is the sum of the capital borrowed in local and world markets; that is,

$$K_X=K_X^d+K_X^f=\beta K_X+(1-\beta)K_X$$

where $K_X^d=\beta K_X$ and $K_X^f=(1-\beta)K_X$ are the domestic and foreign capital used in sector X, respectively.

Foreign capital receives the fixed world rental rate, r^*, while domestic capital receives the common rental rate, r. Thus, the profit of sector X may be expressed as

$$\begin{aligned}\Omega&=pF^X(L_X,K_X,H)-w_sL_X-(rK_X^d+r^*K_X^f)\\&=pF^X(L_X,K_X,H)-w_sL_X-\{r\beta+r^*(1-\beta)\}K_X\end{aligned}$$

It is assumed that all firms seek to maximize profits; then, it holds that

$$\partial\Omega/\partial K_X=pF_K^X(L_X,K_X,H)-\{r\beta+r^*(1-\beta)\}=0$$

Thus, we obtain

$$pF_K^X(L_X,K_X,H)=\beta r+(1-\beta)r^* \quad \text{..... (6)}$$

where r^* is the fixed foreign rental and

$$r = F_K^y(L_y, K_y) \quad \text{..... (7)}$$

Since both domestic and foreign capital are invested in sector X, the effective capital rental rate is the weighted average of the domestic and foreign capital rental rates. Foreign capital receives the fixed world rental rate, r^*, while domestic capital receives the common rental rate, r. It is natural to assume that r is higher than r^* in the model employed in this paper.

The labor employment conditions in the host country are represented as

$$L_x + L_y = L \quad \text{..... (8)}$$

Finally, the employment condition of domestic capital is[2]

$$\beta K_x + K_y = K^d \quad \text{..... (9)}$$

Thus, foreign capital may be expressed as

$$K_x^f = (1-\beta)K_x \quad \text{..... (10)}$$

This completes the specification of the model employed in this paper. We have eight unknown variables— $r, w, w_x, L_x, L_y, K_x, K_y$, and K_x^f – that are solved by eight equations, (4)–(10), for the given parameters r^*, p, K^d, L, H, and β.

3. EQUITY CONTROL AND INCOME DISTRIBUTION

3-1. The change in wage rates

This section examines the effects of the changes in the domestic capital requirement rate (β) on the factor rewards. Differentiating (4)–(10) and arranging terms with respect to the key variables, we obtain

$$\begin{bmatrix} pF_{HL}^x & 0 & pF_{HK}^x & 0 & -1 & 0 & 0 \\ pF_{KL}^x & 0 & pF_{KK}^x & 0 & 0 & 0 & -\beta \\ 0 & F_{KL}^y & 0 & F_{KK}^y & 0 & 0 & -1 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ -pF_{LL}^x & F_{LL}^y & -pF_{LK}^x & F_{LK}^y & 0 & 0 & 0 \\ 0 & 0 & \beta & 1 & 0 & 0 & 0 \\ 0 & F_{LL}^y & 0 & F_{LK}^y & 0 & -1 & 0 \end{bmatrix} \begin{bmatrix} dL_x \\ dL_y \\ dK_x \\ dK_y \\ dw_x \\ dv \\ dr \end{bmatrix} = \begin{bmatrix} 0 \\ (r-r^*) \\ 0 \\ 0 \\ 0 \\ -K_x \\ 0 \end{bmatrix} d\beta + \begin{bmatrix} 0 \\ 0 \\ 0 \\ dL \\ 0 \\ dK^d \\ 0 \end{bmatrix}$$

..... (11)

2 See Hill and Mendez (1992) for this formulation of the domestic capital market.

By solving (11) for w_x with respect to β, we have

$$dw_x/d\beta = [(r-r^*)\{(pF^2_{HL}pF^1_{LK} - pF^1_{HK}pF^1_{LL}) - F^2_{LL}pF^x_{HK}\} - K_y F^y_{KK}(k_y - \beta k_x)(pF^1_{HL}pF^x_{KK} - pF^x_{HK}pF^1_{LK})]/\Delta \quad \text{..... (12)}$$

where Δ is the value of the determinant of the coefficient matrix of the equation system; that is,

$$\Delta = -[\Pi + F^1_{KK}\{\beta^2 pF^y_{LL} + 2\beta k_y pF^x_{LK} + (k_y)^2 pF^y_{KK}\}] < 0 \quad \text{..... (13)}$$

where $\Pi = F^2_{LL}F^1_{KK} - F^2_{LK}F^2_{KL}$. It can be seen that $\Delta < 0$ since $\Pi > 0$ and the quadratic form in the curly brackets in (14) is negative definite because of the property of the production function.

In addition, from (11), we obtain

$$dw/d\beta = F^y_{LK}[\tilde{r}pF^1_{LL}\{\beta(r-r^*)/\tilde{r} - \xi^x_{KK}\} + pF^x_{LK}\{(r-r^*)k_y - k_y\xi^1_{KL}\}]/\Delta \quad \text{..... (14)}$$

where $k_x = K_x/L_1$, $k_y = K_y/L_y$, $\xi^1_{KK} = -(K_x/\tilde{r})pF^1_{KK}$ and $\xi^2_{KL} = (L_1/\tilde{r})pF^1_{KL}$. Thus, we have the following proposition.

Proposition 1.

An increase in the domestic capital requirement rate lowers the skilled wage rate (w_1) if $\beta k_y > k_y$, and it raises the unskilled wage rate (w_1) if $\xi^1_{KK} < (r-r^*)/\tilde{r}$ and $\xi^2_{KL} > (r-r^*)k_y/k_x$.

In order to interpret the results, let us examine the effects of the change in the domestic capital requirement rate on resource allocation. From (11), we obtain

$$dK_x/d\beta = -\{(r-r^*)(F^y_{LL} + pF^x_{LL}) + K_2(F^y_{LK}pF^x_{KL} - \beta F^y_{KK}pF^x_{LL})\}/\Delta \quad \text{..... (15)}$$

Note that

$$(F^y_{LK}pF^x_{KL} - \beta F^y_{KK}pF^x_{LL}) = F^y_{KK}\{(\beta k_x - k_y)pF^x_{LK} + pF^x_{KH}h_x\} \quad \text{.....(16)}$$

where $h_2 = H_x/K_2$. Thus, it can be seen that $dK_x/d\beta < 0$ if $\beta k_x > k_y$.

Thus, the increase in the domestic capital requirement rate increases the effective rental and decreases the employment of foreign and domestic capital if sector X is strongly capital intensive in the sense that $\beta k_2 > k_y$. The domestic

capital released from sector X will be absorbed in sector Y, thus contracting sector X and expanding sector Y. Accordingly, labor also will be reallocated from sector X to sector Y. Thus, because the capital and labor are withdrawn from sector X, the skilled wage rate decreases owing to the decrease in the value marginal product of skilled labor. On the other hand, more labor will be required in sector Y than that released from sector X because the former is more labor intensive than the latter. Furthermore, if the value marginal product of capital is inelastic to capital and elastic to labor employed in sector X (i.e., $\xi_{KK}^{x} < (r-r^*)/\tilde{r}$ and $\xi_{KL}^{x} > (r-r^*)k_y/k_x$, then large amount of capital is reallocated from sector X to sector Y. Thus, this increases the value marginal product of labor in sector Y and tends to increase the unskilled wage rate.

The following proposition can be made on the basis of the result on the changes in the skilled and unskilled wage rates.

Proposition 2.

An increase in the domestic capital requirement rate improves the skilled-unskilled wage inequality if $\beta k_x > k_y$, $\xi_{KK}^{x} < (r-r^*)/\tilde{r}$ and $\xi_{KL}^{x} > (r-r^*)k_y/k_x$

This implies that the equity control policy has a positive effect on wage inequality. This paper shows that equity control decreases wage inequality if sector X is strongly capital intensive relative to sector Y, and the value marginal product of capital is inelastic to capital and elastic to labor employed in sector X (i.e., $\xi_{KK}^{x} < (r-r^*)/\tilde{r}$ and $\xi_{KL}^{x} > (r-r^*)k_y/k_x$.

3-2. The change in the rental of domestic capital

Now, let us examine the change in the rental rate of domestic capital. From (11), we obtain

$$dr = F_{KL}^{y}dL_y + F_{KK}^{y}dK_y = -(F_{LL}^{y}dL_y + F_{LK}^{y}dK_y)/k_y = -dw/k_y \quad \text{..... (17)}$$

Thus, from (14) and (17), the following proposition can be easily deduced.

Proposition 3.

An increase in the domestic capital requirement rate decreases the rental of domestic capital if $\xi_{KK}^{x} < (r-r^*)/\tilde{r}$ and $\xi_{KL}^{x} > (r-r^*)k_y/k_x$

From (11), it can be seen that

$$dK_y/d\beta = [F_{LL}^{y}\tilde{r}\{(r-r^*)/\tilde{r} - \xi_{KK}^{x}\} + \beta\{(r-r^*)pF_{LL}^{x} - K_x F_{KL}^{x} pF_{LK}^{x}\}/\Delta \quad \text{..... (18)}$$

Thus, domestic capital employment in sector Y as a result of the increase in the domestic capital requirement rate increases under the assumption that $\xi_{KK}^{X} < (r - r^{*})/\tilde{r}$. This, in turn, decreases the domestic rental along the value marginal product of capital in sector Y, while the increase in the employment of unskilled labor increases the rental since $F_{LK}^{Y} > 0$ Proposition 3 shows that the former effect is dominant and the policy eventually decreases the domestic rental under the assumption.

On the other hand, from (11), we have

$$dr/d\beta = \{K_{1}F_{KK}^{Y}\Pi - (r - r^{*})(F_{KL}^{Y}pF_{1K}^{2} - \beta F_{KK}^{Y}pF_{LL}^{1})\}/\Delta \quad \text{..... (19)}$$

Thus, it can be seen alternatively that the rental will decrease if skilled labor is independent of labor and capital in the production of sector X. Then,

$F_{LH}^{1} = F_{KH}^{X} \cong 0$, which implies that $\Pi = (F_{LL}^{2}F_{KK}^{X} - F_{KL}^{X}F_{LK}^{1}) \cong 0$. Conversely, it will increase if the difference between the domestic and foreign rentals is sufficiently small. In any case, our result shows that the equity control policy allocates domestic capital from the multinational sector to the domestic sector, and it may have a detrimental effect on the domestic rental.

4. IMMIGRATION AND WAGE INEQUALITY

In this section, let us examine the effects of the increase in unskilled labor due to immigration or population growth on the factor rewards and the wage inequality in the presence of equity control. It is commonly observed that there is an extensive inflow of foreign workers to newly industrialized countries from neighboring developing countries.

It can be seen from (11) that

$$dw_{3}/dL = -F_{LL}^{Y}(\beta k_{2} - k_{y})\{pF_{LK}^{2}(k_{3}pF_{HK}^{1} + pF_{HL}^{X}) + h_{1}pF_{HL}^{X}pF_{HK}^{X}\}/k_{2}k_{y}\Delta \quad \text{..... (20)}$$

and

$$dw/dL = -F_{LL}^{Y}\Pi/\Delta \quad \text{..... (21)}$$

Thus, the results are summarized in the following proposition.

Proposition 4.

The increase in unskilled labor decreases (increases) the skilled wage rate if and only if $\beta k_{2} > (<) k_{y}$, while it decreases the unskilled wage rate.

Proposition 4 shows that the increase in unskilled labor decreases the unskilled wage rate unconditionally. However, the effect on the skilled wage rate depends on the factor intensity. If sector X is strongly capital intensive in the sense that $\beta k_1 > k_y$, the increase in unskilled labor expands the labor-intensive sector Y and contracts the capital-intensive sector X. Thus, both domestic capital and unskilled labor are reallocated from sector X to sector Y. This movement of the factors decreases the value marginal product of skilled labor and reduces the skilled wage rate. On the other hand, if $(k_1 >)k_1 > \beta k_x$, domestic capital and unskilled labor move the other way, and the skilled wage rate increases. In this case, sector Y is *capital* intensive in terms of the domestic capital intensity, while the sector is labor intensive in terms of total (foreign and domestic) capital intensity. This causes the reverse movement of the factors, and increases the value marginal product of skilled labor. This eventually raises the skilled wage rate.

Now let us examine the effect on the wage inequality. From (20) and (21), we obtain

$$(dw_s / dL - dw / dL) = -F_{LL}^{Y}\{\beta k_1 - (1+h_2)k_y\}$$
$$\{pF_{LK}^{1}(k_1 pF_{HK}^{X} + pF_{HL}^{1}) + h_2 pF_{HL}^{1} pF_{HK}^{X}\} / k_2 k_y \Delta \quad \cdots\cdots\cdots\cdots (22)$$

Thus, we have the following proposition.

Proposition 5

The increase in unskilled labor decreases (increases) the wage inequality if and only if $\beta k_1 > (<)(1+h_1)k_y$.

The increase in unskilled labor decreases the unskilled wage rate. Therefore, the effect on the wage inequality depends totally on the change in the skilled wage rate. If $\beta k_s < k_y$, the skilled wage rate increases, and then the wage inequality must expand. However, if $\beta k_2 > k_y$, labor growth decreases the skilled wage rate, and then there is a possibility that the wage inequality improves. Our result shows that the wage inequality decreases if and only if $\beta k_2 > (1+h_x)k_y$, The condition will be met if sector X is strongly capital intensive and/or equity control is very stringent. In this case, large amount of capital and unskilled labor are withdrawn from sector X. This has strong pressure to push down the skilled wage rate, thus possibly resulting in the decrease in the wage inequality

Finally, let us make a brief remark on the effect of capital accumulation on the wage inequality. It can be seen from (11) that capital inflow has exactly the opposite effect than the effects of the increase in unskilled labor. The increase in the domestic capital increases (decreases) the skilled wage rate if and only if

$\beta k_{\backslash} > (<) k_{\nu}$, while it increases the unskilled wage rate. Furthermore, it can be shown that capital accumulation decreases (increases) the wage inequality if and only if $\beta k_{\backslash} > (<)(1+h_{x})k_{\nu}$. This implies that the policy makers must consider the difference of the effects between labor growth and capital accumulation on the wage inequality when they induce foreign labor or accumulate capital as a development strategy.

5. CONCLUDING REMARKS

This paper examined the effects of the equity control of MNFs on income distribution and wage inequality in developing (host) countries. The main finding is that restrictions on multinational investment may lower skilled wage rate and increase unskilled wage rate. Therefore, this restrictive policy may decrease the wage gap and improve wage inequality. The equity control policy was originally formulated to protect domestic capital from FDI by MNFs. However, as far as the effect on income distribution is concerned, the increase in the domestic capital requirement rate may decrease the rental of domestic capital. Furthermore, the increase in labor forth may decrease the wage gap if MNF sector is strongly capital intensive and/or equity control is very stringent.

The increase in the domestic capital requirement rate decreases the inflow of foreign capital as well as the employment of domestic capital in the MNF sector if the MNF sector is strongly capital intensive. The domestic capital is reallocated from the MNF sector to another sector. However, the latter sector is more labor intensive than the MNF sector, thus possibly resulting in an increase in the unskilled wage rate and a decrease in the rental of domestic capital. This suggests that the equity control policy may have some other purpose, for example, to prevent the monopoly of foreign MNFs and to limit their market power in the host countries, along with introducing new and superior technologies into the country.

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Cournot competition: a brief survey

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1 INTRODUCTION

The classical Cournot (1838) model is one of the most important tools in oligopoly theory. In this short paper we provide a brief survey of the important results on existence, uniqueness and stability of the Cournot equilibrium. We will try to provide the most important results on the three topics in a unified framework and also show in the end that a simple condition ensures all three (viz. existence, uniqueness and stability). Since the Cournot model is an workhorse model, this survey should be of some interest to researchers who use imperfectly competitive models for their analyses.

In this model, a small number of firms compete in a homogeneous product market. The firms simultaneously select the amount of output to be sold in the market. The aggregate output level then determine the market price[1] according to the inverse demand function. The process by which the market clears is left unspecified or assumed to be done by an auctioneer. A Cournot game is a quantity setting game where the strategy spaces are the sets of quantities (typically the set of non-negative real numbers) and the payoffs are the profits accruing to the firms. A Cournot equilibrium is just a Nash equilibrium of this game. We will now provide the model of Cournot competition[1].

2 COURNOT COMPETITION: THE MODEL AND NOTATIONS

There are n firms in a homogeneous product market. We denote the inverse demand function by P (X). Demand is strictly decreasing in X, which is the aggregate level of output, x_i, is the output of firm i. Clearly $X = \sum x_i$. Each firm's cost function is given by $C_i(x_i)$. Costs are strictly increasing in x_i. Let $A = \{y \in [0,\infty) \mid P(y) > 0\}$. We assume that the demand and the costs are twice continuously differeiitiable over A.

1 Tirole (1988) and Vivcs (1999) provides an adequate coverage of the main results in the literature.

Let $X_{-i}=\sum_{j\neq i} x_j$ denote the aggregate of all firm's output other than *i*. The payoff to each firm is its profit and this depends on its own output and the aggregate of other firm's output . We denote the payoff to firm *i* by $\pi_i(x_i,X_{-i})=x_iP(X)-C_i(x_i)$. Let $r_i(X_{-i})$ = $\text{argmax}_{x_i}\pi_i(x_i,X_{-i})$ denote the best response correspondence of firm *i*.

A Cournot- Nash equilibrium is a vector of outputs $x^* = (x^*_1, x^*_2 ...x^*_i,...x^*_n)$ such that for all *i*, $x^*_i \in r_i(X^*_{-i})$.

We now introduce the following notations.

$$\mu_i(x_1,x_2,...x_n)=\frac{\partial \pi_i}{\partial x_i}=x_iP'(X)+P(X)-C_i'(x_i)$$

$$a_i(x_1,x_2,...x_n)=\frac{\partial^2 \pi_i}{\partial x_i^2}=x_iP''(X)+2P'(X)-C_i''(x_i)$$

$$b_i(x_1,x_2,...x_n)=\left.\frac{\partial^2 \pi_i}{\partial x_i \partial x_j}\right|_{j\neq i}=x_iP''(X)+P'(X)$$

It may be noted that μ_i is the *ith* firm's marginal profit, a_i is the rate of change in the *ith* firms marginal profit w.r.t change in its own output and b_i the rate of change in the *ith* firm's marginal profit w.r.t. the change in the *jth* firm's output. Since we consider a homogeneous product market, it does not matter which of the *jth,* firm changes its output. To the *ith* firm what only matters is the sum of the outputs of all other firms.

Note that $a_i - b_i = P'(X)-C_i''(x_i)$. Also note that if $r_i(X_{-i})$ is a differentiable function then

$$r_i'(.)=-\frac{b_i}{a_i}.$$

Since at a regular equilibrium a_i < 0, the sign of $r_i'(.)$ is the same as the sign of b_i.

Following Bulow *et al.* (1985) we can say that if $b_i < 0$ (that is the best response function is downward sloping) then the products are *strategic complements.*[2]

3 EXISTENCE COURNOT EQUILIBRIUM

The existence of Cournot equilibrium has been analysed by various theorists over the last few decades. We provide a brief account of this literature below.

From the standard existence theorems'[3] it follows that, if one assumes that (*i*) the strategy sets are closed interval of the real line (ii) $\pi_i(x_i, X_{-i})$ is continuous and (iii) $\pi_i(x_i, X_{-i})$ is quasi-concave in x_i then a Cournot equilibrium will exist.

Earlier papers on existence (example Frank and Quandt, 1903) assumed simple concavity of profit functions. A sufficient condition for this is that the inverse demand is concave and costs are convex. A later contribution in this genre is Szidarovsky and Yakowitz (1977).

However, the conditions assumed in the above literature are very strict. Profit function often fails to be concave (or quasi-concave). It may not be concave (or quasi-concave), particularly, if the demand function is sufficiently convex. Roberts and Sonnenschein (1977) and Friedman (1983, pp. 67-69) provide examples where the Cournot equilibrium fails to exist. The lack of quasi-concavity in the payoffs introduces discontinuities in the best response functions of the firms and this results in non-existence of equilibrium.

A different approach towards the existence problem is due to McManus (1962 and 1964) and Roberts and Sonnenschein (1970). These papers allow for general demand functions but assume cost function to be identical and convex. The assumptions imply that jumps in the reaction function (which are same for all firms, as costs are identical) are jumps up. Then application of Tarski fixed point theorem gives the existence of a symmetric Conrnot equilibrium. Amir and Lambson (2000) proves existence of symmetric Cournot equilibrium under a weaker condition, viz. $C^*(.) > P'(.)$ (i.e. $a_i < b_i$). Here it may be mentioned that

2 Conventional substitutes and complements can be distingished by whether a more "aggressive" strategy by firm (e.g.. lower price in price competition, greater (quantity in quantity competition, increased advertising, etc.) lowers or raises its rival's total profits. Strategic substitutes and complements arc analogously defined by whether a more "aggressive" strategy by firm lowers or raises its rival's marginal profits.

3 See Fudenberg and Tirole (1991) for the standard theorems on existence of Nash equilibria. Reny (1990) provides a succinct survey and also some significant results on existence.

Schipper (2002) provides a detailed and a more complete proof of the existence of symmetric Cournot equilibrium using this approach.

Another extremely important contribution is by Novshck (1985)[4]. Tliis approach allows for general cost functions[5] hut requires demand functions to be well behaved. The key assumption on the demand function is that the marginal revenue of any firm must be declining with the aggregate output of the rest. This means $b_i < 0$. The decreasing marginal revenue assumption implies that the best response correspondences are strictly decreasing (i.e products are strategic substitutes). Then a straightforward application of the fixed point theorem with decreasing best responses will give the existence of Cournot equilibrium, (see theorem 2.7 in Vives. 1999). *In short, Novshek (1985) demonstrated that if $b_i < 0$ then a Cournot equilibrium always exits.*

A weaker sufficient condition for strictly decreasing best response correspondences is that demand $P(X)$ should be log concave. This was shown by Amir (1996). It may be mentioned here that Kukushkin (1994) provides a very general theorem for decreasing best response correspondences. However, Novshek (1985) remains one of the most important contributions in the literature on existence of Cournot equilibrium[6].

Recently, a different approach to existence deals with cases where the Cournot game is a su-permodular game. A rough idea of the attack on the existence problem within this approach is as follows: Tarski's theorem shows the existence of a fixed point for increasing functions. One can use it then when best-reply correspondences of players have a monotone increasing selection. This monotonicity property is guaranteed when the marginal profit increases with the outputs of rivals (i.e.. when the game exhibits 'strategic complementarity')[7]. The results of such an approach not only show existence of equilibrium without requiring quasiconcavity of payoffs but also obtain order properties of the equilibrium set like the existence of a largest, and a smallest equilibrium point. Amir (1990) provides conditions that turn the Cournot game into a supermodular game. Vives (1999) gives a superb account of this approach.

Lastly, we can mention a paper by Svizzero (1997). Normally, existence is proved by putting some form of concavity restrictions on the demand and/or profit functions. As a point of departure, this paper proves the existence of Cournot Equilibrium with convex demand but with linear costs.

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4 It may be mentioned here that Bamon and Fraysee (1985) has a related result.

5 Costs are required to be. lower semi-continuous.

6 Here it may be mentioned that Novshek (1984) demonstrates a neat way of finding all *n*-firm Cournot equilibra.

7 Note that strategic complementarity exits when $b_i > 0$

4 UNIQUENESS OF COURNOT EQUILIBRIUM

Conditions guaranteeing imiqueness of Cournot equilibrium are second only to those guaranteeing existence in terms of importance of both theoretical and applied analyses. It is clear that while the Cournot equilibrium may exist under quite general conditions; uniqueness of equilibrium is not so general, as reaction functions may intersect more than once. Friedman (1977) provides conditions under which equilibrium is unique. A very strong sufficient condition is (see Shapiro, 1989)

$$a_i + (n-1)|b_i| < 0, i = 1,2...n \text{-----} (1)$$

A little introspection will suggest that the above condition is far too strong, especially more than two firms. This can be easily checked with linear demand and constant marginal costs.

There are other papers which provide sufficient conditions for uniqueness of Cournot equilibrium. Szidarovszky and Yakowitz (1977 and 1982) prove uniqueness with concave inverse demand and convex costs. Okuguchi (1983) establishes uniqueness through certain restrictions on demand and costs in such a way so as to use the Gale- Nikaido theorem (1965).

However, one of the most important results on this topic till date is due to Kolstad and Math-iesen (1987), who develop a theorem giving necessary and sufficient conditions for uniqueness[8]. They show an equilibrium $x^* = (x^*_1, x^*_2 ..... x^*_i, ... x^*_n)$ is unique if and only if for all equilibria x*.

$$(-1)^n \left\{ \prod_{i=1}^{n} (a_i - b_i) \right\} \left\{ 1 + \sum_{i=1}^{n} \frac{b_i}{a_i - b_i} \right\} > 0 \text{.....} (2)$$

---

8 The Kolstad and Mathiesen model is based on the following additional assumptions.
(i) Industry output is bounded. Industry output is said to he bounded if there is a compact subset K of R^N_+, such that for

for $(\bar{x}_1, \bar{x}_2 ..... \bar{x}_n) \in R^N_+ \setminus K$, $\mu_i (\bar{x}_1, \bar{x}_2 ..... \bar{x}_n) < 0, \forall i$.

The above means that industry output is bounded if there is an output level for which all $\mu_i s$ are negative and furthermore these negative $\mu_i s$ persist for all greater industry output levels.

(ii) For all i, $\pi_i (\bar{x}_1, \bar{x}_2 ..... \bar{x}_n)$ are pseudo concave w.r.t to own output.

(iii) All Cournot equilibria (if any) are non-degenerate. This means that

$$x^*_i = 0 \in P\left(\sum x^*_j\right) < C'_i(0)$$

The above implies that in any equilibrium a firm is either clearly in the market or out of it.

If we assume $a_i < b_i \left(\Leftrightarrow P' < C_i^{11}\right)$ then $(-1)^n \left\{\prod_{i=1}^{n}(a_i - b_i)\right\} > 0$ (regardless of whether n is 'even' or 'odd'). On top of this if we also assume that $b_i < 0$ then

$$\prod_{i=1}^{n} \frac{b_i}{a_i - b_i} > 0 \Rightarrow (-1)^n \left\{\prod_{i=1}^{n}(a_i - b_i)\right\}\left\{1 + \sum_{i=1}^{n} \frac{b_i}{a_i - b_i}\right\} > 0$$

Remark

This shows $a_i < b_i$ *and* $b_i < 0$ together imply that the Courtot equilibrium is unique.

It may he noted that the Kolstad- Mathiesen result, depends on the assumption of non-degeneracy of Courriot equilibrium. Gaudet and Salant (1991) drops this non-degeneracy assumption and provides another sufficient (not necessary) condition for uniqueness.

5 STABILITY OF COURNOT EQUILIBRIUM

Analyses of stability of Cournot equilibrium has a long history. Stability of equilibrium is very important for comparative statics. Since in most IO models that use Cournot competition, various comparative static exercises are carried out; analysis of such stability conditions is very important. Vives (1999) provides a succinct summary of the literature.

Following the seminal paper by Theocharis (1960) a number of economists have worked on this problem. Fisher (1961) is an early contributor.

One of the most influential papers of this early era is Hahn (1962). He uses the following adjustment, system.

$$x_i = k_i\left(x^*_i - x_i\right),\ i = 1,\ 2.....n,\ k_i > 0$$

He shows that if $a_i < b_i$ and $b_i < 0$ then the Cournot equilibrium is globally stable. However, there was a problem in the proof of Hahn's paper. Al-Nowaihi and Levine (1985) rectifies the error and show that the Halm condition ensures global stability only for $n \leq 5$.. However, it ensures local stability for all n.

Other contributions on stability include Okuguchi (1976 and 1998), Seade (1980), Deamange (1986) etc.

In an influential paper Dixit (1986) discusses local stability. He uses a myopic adjustment process where each firm increases its output starting at a given point $\left(x_1, x_2, ...x_n\right)$) if it perceives positive marginal profits from doing so. That is,

$x_i = s_i \frac{\partial \pi_i}{\partial x_i}$, where $s_i > 0$ are the adjustment speeds.

One of the necessary conditions for local stability is the following..

$$\sum s_i a_i < 0 \quad (N1)$$

The other necessary condition is given by

$$(-1)^n \left\{\prod_{i=1}^{n}(a_i - b_i)\right\}\left\{1 + \sum_{i=1}^{n}\frac{b_i}{(a_i - b_i)}\right\} > 0. \quad (N2)$$

The simplest set of *sufficient* conditions is given by

$$|a_i| > (n-1)|b_i|. \quad (S1)$$

Remark

1. Note that (SI) is same as (1). This means that if this condition is satisfied, both uniqueness and local stability are ensured.

2. Condition (2) ensures uniqueness under a weaker sufficient condition. Using (2) we get that uniqueness of Cournot equilibrium implies

$(-1)^n \left\{\prod_{i=1}^{n}(a_i - b_i)\right\}\left\{1 + \sum_{i=1}^{n}\frac{b_i}{(a_i - b_i)}\right\} > 0$. It may be noted that at an *regular* and *interior* Cournot equilibrium for all i, $a_i < 0$ and together with (2) this in turn means that a regular, unique, interior Cournot equilibrium satisfies (Nl) and (N2).

Dastidar (2000) poses the following question- Is a unique Cournot equilibrium locally stable? Using the same adjustment process as Dixit (1986) and the same conditions of Kolstad and Math-iesen (1987) for uniqueness, Dastidar (2000) shows that a unique Cournot equilibrium is locally stable under very general conditions. He proves the following results.

1. In a homogeneous product duopoly a regular, unique Cournot equilibrium is always locally stable.
2. For a, *n*-firm oligopoly a regular, unique Cournot equilibrium is always locally stable if at the equilibrium for all i, either $b_i \leq 0$ or for all i, $b_i > 0$. *This means that if either all firms have negatively sloping reaction functions* $(b_i > 0)$ *or if all firms have positively sloping reaction*

functions $(b_i > 0)$ *then a unique Cournot equilibrium is locally stable.*

Dastidar (2000) also analyses the case where $b_i s$ have different signs in equilibrium (i.e some firms have negatively sloping reaction functions and the other firms have positively sloping reaction functions). Without loss of generality let us suppose that in equilibrium $b_i \leq 0$, for i = 1, 2....., m. and b > 0 for $i = m + 1, m + 2.....$, n. where $0 < m < n$. Let $r_i' = \left(-\frac{b_i}{a_i}\right)$. As noted before, r_i' is the slope of the *ith* firm's reaction function.

3. This brings us to the next main result of Dastidar (2000).
   (a) If $n - m = 1$, then a regular, n-firm unique Conrnot equilibrium is always locally stable.
   (b) If $n - m > 1$, then a regular, unique Cournot equilibrium is always locally stable provided

$$|r_i'| \leq \frac{1}{n-m-1} \text{ for } i = m + 1, m + 2,....., n.$$

The last result is clearly much less restrictive than what is required in (S1) (see also Seade, 1980). It may be recalled that (SI) requires that

$$\forall i,\ (n-1)|b_i| < |a_i|,\ \Leftrightarrow |\forall i,\ |r_i'| < \frac{1}{n-1} \text{.....(3)}$$

On the other hand, the last, result stated above requires that

$$|r_i'| \leq \frac{1}{n-m-1} \text{ for } i = m+1, m+2, \text{ .....}, n \text{.....(4)}$$

Note that, the R.H.S. of (4) is greater than the R.H.S. of (3), which makes it a less restrictive condition. Moreover, this result imposes no restrictions on the value of the slopes of the reaction functions of firms that have negatively sloping reaction functions in equilibrium (i.e. for i = 1, 2....., m}. Loosely speaking, this requires that demand function should not be too convex.

There are other important papers which deal with stability (and instability) when there fire multiple equilibria. Furth (1985) arid Bonanno (1988) fall in this category. Zhang and Zhang (1996) deals with stability in the multiproduct case.

Final Remarks

Study *of* any equilibrium entails analyses of three aspects viz existence,

uniqueness and stability. If we assume that $a_i < b_i \left(\Leftrightarrow P' < C_i''\right)$, which is satisfied *by* most demand and cost combinations[9], then we get the following.

1. If $b_i < 0$ then the Conrnot equilibrium always exists (Novshek, 1985), it is unique (Kolstad and Mattnesen, 1987) and locally stable (Dastidar. 2000).
2. In short, if products are strategic substitutes $(b_i < 0)$ then all three, viz. existence, uniqueness and local stability of Conrnot equilibrium are guaranteed under quite general conditions.

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ASI Database & Firm-level Technical Efficiency: The Case of Indian Chemical Sector[1]

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Abstract

This paper attempts to describe the scope, coverage, quality, advantage and limitation of ASI data in context of assessment of the performance of Indian Chemical Sector. Manufacturing sector plays a significant role for economic growth in India and chemical sector is one of the dominant sectors within the manufacturing sector. With respect to product and process diversity, the Indian chemical industry holds an important position From the organizational point of view also there exists duality in terms of size (large, medium and small firms), in terms of employment (regular vis-à-vis contractual), capital use (types of financing) and production units (formal and informal) Moreover the industry is characterized in terms of vertical and horizontal linkages as well as pollution sensitivity. Since ASI provides database compatible with a few of these classifications in this paper an attempt has been made to measure the technical efficiency of this sector at all India level through Non-Parametric Data Envelopment Analysis (DEA). Due to availability of input and output related data in value terms for each registered factories this kind of analysis has become possible with ASI data. In fact, the information base may be used to assess total factor productivity as well. Here an attempt has been made to explain where the database is useful and where it lacks generality. Three important observations may be listed as follows:

(i) Given the available data at the factory level no longitudinal comparison is possible to check the efficiency profile of any particular class of firms over the phases of policy changes. The firm identification code, if generated, would be really helpful in carrying out panel data analysis,

(ii) Since no information about prices are available, only the status of technical efficiency can be assessed but not that of the allocative efficiency; Here the figures, if reported in terms of both physical volume/ number and value may help to proxy average price in some indirect way;

(iii) Finally, the abundance of missing observations at times limit the effective database to unusually small size that makes it inappropriate to carry out the overall efficiency analysis;

Keywords: ASI database, Chemical Industry, Non-Parametric Data Envelopment Analysis, Total Factor Productivity.
JEL Classification: L67

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I. INTRODUCTION

Production is an act of transforming inputs into output. The objective of production is to create value through transformation and, therefore, outputs are in general desirable outcomes. Hence, more output is better. At the same time inputs are valuable resources with alternative uses. The objective of a firm can be stated as either to produce as much output as possible from a specific quantity of input or to produce specific quantity of output using as little input as possible. An input output combination is a feasible production plan if, given the state of technological knowledge, the output quantity can be produced from the associated input quantity.

The performance of any production unit can be evaluated in terms of the extent of relative input productivity and the productive efficiency of the unit concerned. Generally productivity is a descriptive measure of performance without any reference to the target level whereas efficiency is a normative measure assessed with reference to the production frontier. If the sector experiences an up-gradation in production technology, then the constituent firm may experience an increase in total factor productivity, where the credit of this improvement cannot be ascribed to any specific factor of production. In fact, total factor productivity refers to the shift in the total production frontier. To estimate productivity and efficiency information is required on input-output structure of the productive units at different levels of aggregation. In India all such researches depend on ASI database as their primary source. This paper attempts to describe the concepts and measures of efficiency in general and comments on the adequacy of ASI database to assess it at the firm level disaggregation. Specific illustrations are provided by taking chemical industry of India as an example. The rest of the paper will be organized as follows: Section II discusses different notions of efficiency like technical efficiency, allocative efficiency, economic efficiency and within technical efficiency distinction is made between input-oriented approach and output-oriented approach. Section III will concentrate on the measurement aspect and the theory of Data Envelopment Analysis (DEA) would be discussed as a popular non-parametric method. Section IV will provide an illustration in terms of efficiency analysis of Indian Chemical Sector by utilizing unit-level ASI data over different years. Finally, section V will conclude the paper by indicating the (in)adequacy of ASI database.

II. CONCEPT OF EFFICIENCY:

The basic objective of the efficiency measurement is the evaluating the performance of decision making agent. In context of production the decision making agent is firm. The choice variables are the quantity of outputs to be produce as well as the quantity of inputs to be used. The input output combination selected by the firm must be technically feasible in the sense that it must be

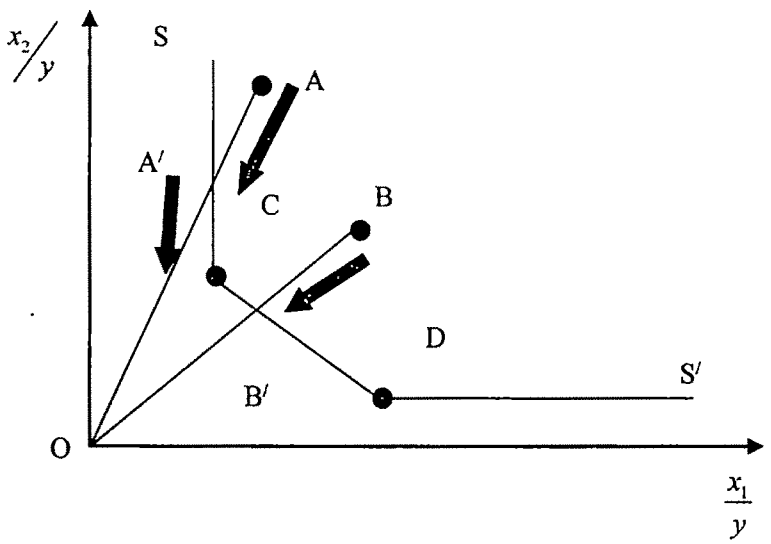
possible to produce the output bundle selected from the associated input bundle. Initially attempts were made to estimate the production frontier by applying parametric econometric techniques (Rastas, 1948). However, inspired from the work of Debru (1951) and Koopmans (1951) a non-parametric methodology for efficiency measurement of a firm was initiated by Farrell (1957) using programming technique. This new approach gained popularity as the modern efficiency measure. According to Farell, the efficiency of a firm consists of two components, viz., (a) technical efficiency and (b) allocative efficiency. These two basically reflect the ability of a firm to use the inputs in optimal proportion, given their respective prices. These to measures are then combined to provide a measure of total economic efficiency. When for a pre-committed level of output the input use is minimized one gets the input-oriented efficiency measure and for a given set of inputs by producing the maximum possible output bundle one gets the output oriented efficiency measure. If an input-output mix is technically feasible without any wastage of input and/or underproduction of output then and then only it is technically efficient. However, the cost of production depends not only on the physical input-output combination but also on the market prices of the inputs and outputs. So, to achieve allocative efficiency a technically efficient combination has to be the least cost one also. In case of ASI database no specific information is available on the market prices. Hence, in rest of the exposition we would concentrate on the analysis of technical efficiency alone.

The concept of efficiency is incompatible with unrealized output potential and/or avoidable input waste. In case of technical efficiency there are two distinct dimensions: firstly, whether the firm has selected the correct **technique** of production or not, i.e., choosing the correct ray (in 2-dimension input-plane), and secondly, if the correct technique is chosen whether the **scale** has been selected optimally or not (i.e., the exact location on the ray). Since an efficient firm has to achieve both, the exact sequencing of choice does not have much bearing on the final outcome. When to select the proper scale one seeks the maximum equi-proportionate increase in all outputs or decrease in all inputs this is known as radial efficiency. However, the radial projection of an observed input-output bundle onto the frontier does not necessarily exhaust the potential for expansion in all outputs or reduction in all inputs. In this case one needs some non radial movement along with production frontier to reach the efficient point. This movement calls for change in input (output)-proportions. Hence, here two types of slacks are encountered (a) input slacks and (b) output slacks. Figures 1 and 2 are explaining the notions of input-oriented and output-oriented technical efficiencies with corresponding illustrations of radial as well as on-fontier movements to illustrate the notion of both technique related inefficiency and scale related inefficiency[2].

2 It will be discussed shortly that for output-oriented technical efficiency the interpretation of radial and slack inefficiencies will just be reversed.

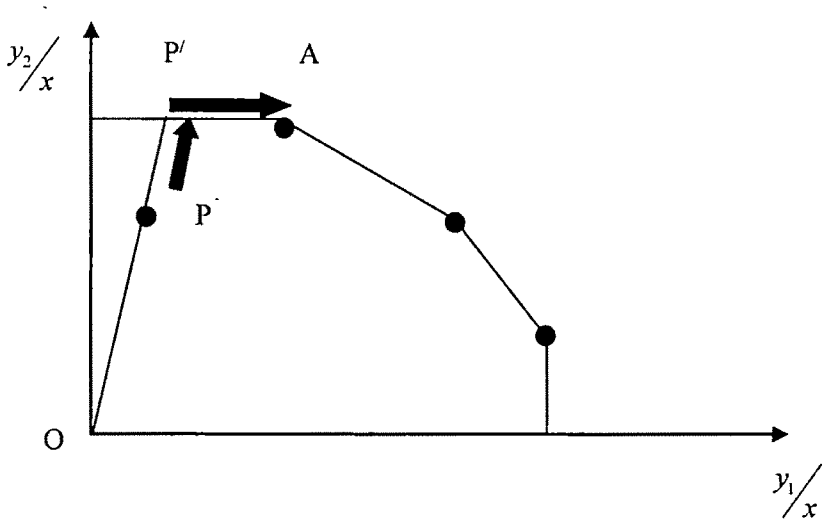
Suppose we have four firms: A, B, C and D of which C and D are the efficient firms. Now with the help of observed input-output data the piecewise linear isoquant (SS′) can be constructed (confer Figure-1) Firms A and B represent two inefficient firms. So, the extent of their technical inefficiency will be $\frac{OA'}{OA}$ and $\frac{OB'}{OB}$ But it is not the ultimate efficient point because one could reduce the input x_2 by the amount CA′ and still produce the same output. Therefore, this movement along isoquant is known as the input slack. On the other hand in case of firm B only radial movement is enough to ensure efficient input-output combination. No slack movement is required here. Similarly the concept of output slack can be described.

Figure-1
Input Oriented Radial and Slack Efficiency



Consider Figure-2 where a firm is operating at P, a point inside the production possibility frontier. The position is clearly inefficient as through a simple radial movement the firm may operate at P′ and enjoy greater amount of both y_1 & y_2. This distance from P to P′ is called the radial inefficiency. However, it is interesting to note that even at point P′ the firm has scope to improve its output basket. A movement along the frontier from P′ to A will help it to increase the amount of y_1 without sacrificing that of y_2, and, hence, the value of total output would certainly be higher at A compared to that at P′. This distance from P′ to A is known as output slack inefficiency.

Figure-2
Output Oriented Radial and Slack Efficiency



In the following section we will describe the programming technique applied to assess this technical efficiency score of a firm. Since ASI data base reports value of inputs and value of output for different production units it is not appropriate to assess the input-oriented technical efficiency of the concerned unit. Here we cannot provide satisfactory answer to the question that whether same bundle of output could be produced with lesser amount of input or not. On the other hand, with this database it can be seen that whether among the available set of firms a particular firm has produced the (relatively) maximum possible output by using the given input bundle. Hence, a relative ranking of the firms in terms of achieved score of output oriented technical efficiency can be obtained (Coelli, *et.al.* 2005).

III. DATA ENVELOPMENT ANALYSIS: A NON-PARAMETRIC APPROACH:

The data Envelopment analysis (DEA) tries to generate the production frontier from the available observed data without making any specific assumption regarding the functional form of the production function. This method was first introduced into the Operation Research (OR) literature by Charnes, Cooper and Rhodes (CCR) in 1978. The mode;l was developed under the assumption of constant returns to scale (CRS) and was subsequently extended to the case of variable returns to scale (VRS) by Banker, Charnes and Cooper (BCR) in 1984. The nonparametric DEA generates the production frontier on the basis of only observed input-output data by applying linear programming (LP) technique.

Without considering the input and output prices the DEA estimates the technical efficiency of a firm which makes it widely popular[3]. In this section we will discuss the mathematical formulation of basic both CCR and BCC models of DEA for the calculation of output oriented technical efficiency (TE) scores.

Under the standard assumptions of feasibility, convexity and free disposability the DEA algorithm generates the frontier under the defined technology and measures the technical efficiency from the calculated distance function from observed point and the generated frontier.

Suppose there is N number of firms in the system and we consider the t^{th} firm. The input output bundle of that firm is: $x^t = (x_{1t}, x_{2t}, ..., x_{mt})$ and $y^t = (y_{1t}, y_{2t}, ..., y_{st})$. To obtain the value of total input used and total output generated by a firm one needs appropriate virtual prices u_{it} and v_{jt} for inputs and outputs respectively. The total value of input used by the t^{th} firm would be $\sum_{i=1}^{m} u_{it} x_{it}$ and the total value of output produced by t^{th} firm would be $\sum_{j=1}^{s} v_{jt} y_{jt}$. The average productivity of the firm t would be $AP_t = \frac{\sum_{j=1}^{s} v_{jt} y_{jt}}{\sum_{i=1}^{m} u_{it} x_{it}}$.

To give virtual prices the status of shadow prices one needs to assume implicitly a perfectly competitive market structure, leaving no scope for supernormal profit. Hence, the production relation has to satisfy the constraint stated as $\sum_{j=1}^{m} v_{jt} y_{jt} \leq \sum_{i=1}^{n} u_{it} x_{it} \forall t$ along with non-negativity restriction on shadow prices. So, the intended programming problem would be:

$$\text{Max: } AP_t = \frac{\sum_{j=1}^{s} v_{jt} y_{jt}}{\sum_{i=1}^{m} u_{it} x_{it}}$$

$$\text{Subject to: } \sum_{j=1}^{s} v_{jt} y_{jt} \leq \sum_{i=1}^{n} u_{it} x_{it}, \ \forall t = 1, 2, ..., N \quad .....\text{Model-1}$$

$$u_{it}, v_{jt} \geq 0$$

3 Being non statistical in nature the LP solution of DEA problem produces no standard error and makes no room for hypothesis testing, express its only limitation.

Two problems may immediately be recognized with respect to this formulation. Firstly, by virtue of the profit constraint the objective function would be a fraction. Moreover, the system is homogeneous of degree zero in prices and therefore, if u_{rt}'s and v_{jt}'s qualify as shadow prices, so would be λu_{rt} and λv_{jt}'s. To handle both these problems simultaneously, a price normalization constraint can be incorporated which will change the programming problem as:

$$\text{Max}: \sum_{j=1}^{m} p_{jt} y_{jt}$$

$$\text{Subject to: } \sum_{j=1}^{m} p_{jt} y_{jt} - \sum_{r=1}^{n} w_{rt} x_{rt} \le 1 \quad \forall t = 1,2,\ldots\ldots\ldots,N \quad \ldots\ldots\ldots\text{Model-2}$$

$$\sum_{r=1}^{n} w_{rt} x_{rt} = 1 \quad w_{rt}, p_{jt} \ge 0 \quad \forall t = 1,2,\ldots\ldots\ldots,N$$

This is a standard Linear Programming Problem and here $w_{rt} = \lambda u_{rt}$ and $\lambda > 0$ with $\lambda > 0$. Since the constraints apply to every firm including firm t, hence the maximum value of the objective function would be $AP_t = 1$ (Raa, 2009).

Therefore, the dual of Model-2 will be:

$$\text{Min: } \theta$$

$$\text{Subject to: } \sum_{t=1}^{N} \lambda_t y_{jt} \ge y_{jt}; \forall j = 1,2,\ldots\ldots\ldots,m$$

$$\sum_{t=1}^{N} \lambda_t x_{rt} \le \theta x_{rt}; \forall i = 1,2,\ldots\ldots\ldots,n \quad \ldots\ldots\ldots\text{Model-3}$$

$$\lambda_t \ge 0; \forall t = 1,2,\ldots\ldots\ldots,N$$

Where: θ is free.

From Model-3 one can estimate θ which is nothing but the input oriented technical inefficiency score of t^{th} firm under CRS assumption. Again if we define $\phi = \frac{1}{\theta}$ and $\mu_t = \frac{\lambda_t}{\theta}$ then minimization of

θ is equivalent with maximization of ϕ In term of redefined variable the LP problem (Model-3) now becomes

$$\text{Max: } \phi$$

$$\text{Subject to: } \sum_{t=1}^{N} \mu_t y_{jt} \ge \phi y_{jt}; \forall j = 1,2,\ldots\ldots\ldots,m$$

$$\sum_{t=1}^{N}\mu_t x_{it} \le x_{it};\forall i=1,2,.....,n \quad .....\text{Model-4}$$

$$\mu_t \ge 0;\forall t=1,2,.....,N$$

Where: ϕ is free.

The score generated from the expression $\frac{1}{\phi}$ is nothing but the output oriented technical efficiency of the t^{th} firm under CRS. These two models was the first generation model of efficiency score measurement known as CCR model. The (in)efficiency measurement with additional constraint $\sum_{t=1}^{N}\lambda_t = 1$ in Model-3 and

$\sum_{t=1}^{N}\mu_t = 1$ in Model-4 express extended version of CCR model known as BCC model which considers the VRS assumption instead of CRS assumption. The BCC model is known as the second generation efficiency measurement model. Both CCR and BCC model is the foundation model of (in)efficiency measurement but both calculate only radial (in) efficiency. For radial and slack calculation together one has to use the third generation algorithm. Using this method the Model-3 and Model-4 becomes:

Min: $\tilde{\theta} = \theta - \varepsilon\left(\sum_{j=1}^{m} s_j^+ + \sum_{i=1}^{n} s_i^-\right)$

Subject to: $\sum_{t=1}^{N}\lambda_t y_{jt} - s_j^+ = y_{jt};\forall j=1,2,.....,m$ Model-5

$$\lambda_t, s_j^+, s_i^- \ge 0;\forall t=1,2,.....,N;\forall j=1,2,.....,m;\forall i=1,2,.....,n.$$

Where: θ is free.

Max: $\tilde{\phi} = \phi + \varepsilon\left(\sum_{j=1}^{m} s_j^+ + \sum_{i=1}^{n} s_i^-\right)$

Subject to: $\sum_{t=1}^{N}\mu_t y_{jt} - s_j^+ = \phi y_{jt};\forall j=1,2,.....,m$

$$\sum_{t=1}^{N} \mu_t x_{it} + s_i^- = x_{it}; \forall i = 1,2,\ldots\ldots\ldots\ldots,n \quad \ldots\ldots\ldots\ldots \text{Model-6}$$

$$\mu_t, s_j^+, s_i^- \geq 0; \forall t = 1,2,\ldots\ldots\ldots\ldots,N; \forall j = 1,2,\ldots\ldots\ldots\ldots,m; \forall i = 1,2,\ldots\ldots\ldots\ldots,n.$$

Where: θ is free.

s_j^+, s_i^-, basically indicates the output and input slack and ε is any pre-assigned positive number, however small. Positive sign means output should be increased and negative signed means input should be decreased (Ray, 2004). Most of the computer packages in recent time run either Model-5 or Model-6 program to estimate the input or output oriented radial and slack (in)efficiency.

IV. Application of DEA on Indian Chemical Industry:

In India the manufacturing sector plays a significant role in promoting economic growth. The chemical sector is especially important not only for its size but for wide range of product diversity as well. According to National Industrial Classification Code 1998 (NIC98) at 1-digit level of classification manufacturing sector is given the code 2; at two digit level the chemical sector is coded as 24 and in three digit level it is further subdivided into three broad categories lke (1) Manufacture of basic chemicals (241), (2) Manufacture of other chemical products (242) and (3) Manufacture of man-made fibers (243). Again each of these three 3-digit categories are subsequently divided into finer ones generating nine 4-four digit categories according to the product diversification. The firm level information in ASI database is reported at the 5-digit level of disaggregation where Chemical industry has fifty seven categories according to the nature of end products of the units. Flow chart 1 shows the method of disaggregation of chemical industry in terms of NIC categories and explains how at the higher levels of disaggregation more specific product varieties can be captured.

By applying DEA technique on the firm level data available at the 5-digit level for this sector we will attempt to find out:

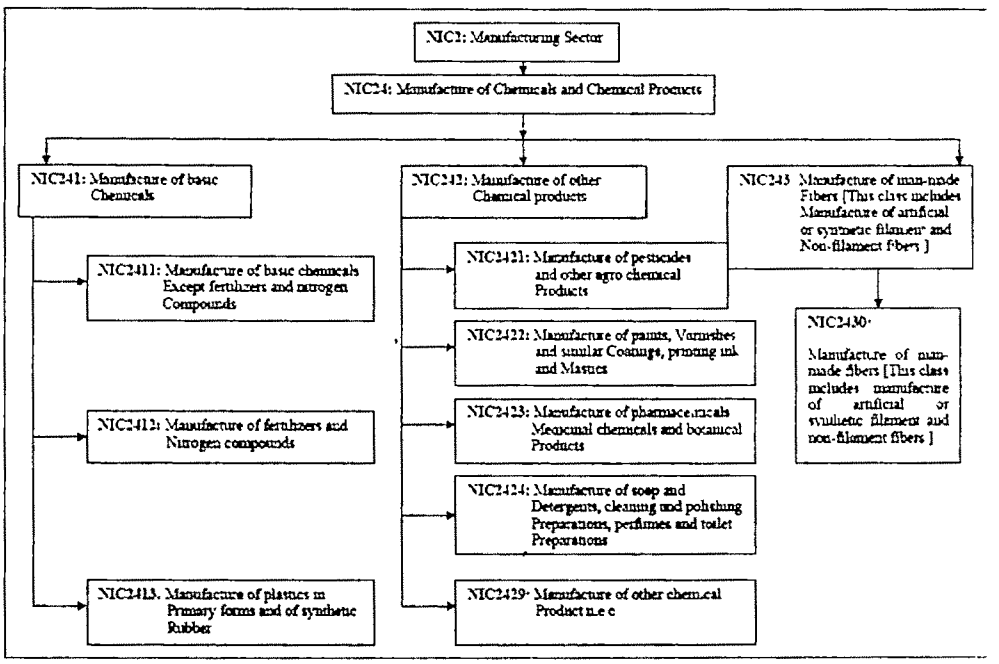
(a) **the change in the pattern of distribution of the technical efficiency scores for some selected years in the recent past: 1999-2000, 2001-02, 2003-04 and 2005-06.**

Through temporal comparison of the pattern of efficiency distribution this study will help us to assess the adaptability of this industry with the economic optimism generated in the post-reform, post-WTO regime through high growth rates of GNP. Whether the forces of globalization are helping the sector to gain in terms of technical efficiency at all India level is our primary concern.

At the next stage:

(b) **a state-level analysis has been carried out to identify the major states participating in chemical production. Here, by following the meta-frontier technique an analysis of technology gap is proposed in terms of comparison of the distance between grand frontier and group frontier.**

Flow Diagram-1
NIC Classification of Chemical Industry[4]



In Meta-frontier analysis the firms are first classified into different groups based on certain criteria and the group specific frontiers are constructed to estimate the efficiency of the firms against the group frontier. Further a global or grand frontier is also calculated by considering all firms in the sample and the efficiency of the firm is also calculated with reference to the grand frontier. The ratio of efficiency of a firm between the local and global frontier is defined as the technology gap ratio, which shows the additional efficiency that a firm may gain if the choice of group would be a free choice to it.

To address the first question this paper attempts to estimate the all India level output oriented technical (radial and slack) efficiency of each firm for the selected years by using Model-6. On the other hand for the same set of time-periods the region specific Meta-frontier analysis proposed by Battese and Rao (2002) and Battese, Rao and O'Donnell (2004) would be applied to answer the second question.

4 This flow chart illustrates the method of disaggregation and classification up to 4-digit level and that for 5-digit level has been reported in Appendix A.

Input-Output Structure:

Technical efficiency assessment needs a very precise specification of input output structure. The TE score is sensitive to the choice of inputs and outputs. Though there is no hard and fast guideline available for the selection of input and output, this paper follows the practice adopted in Bhandari (2009) reported below.

- **Output**: the total ex-factory value of products and by-products produced by the firm during the year in question (to be denoted by OUT).
- **Intermediate Inputs:** the nominal value of inputs (addition of indigenous and imported ones, including power, fuels etc.) used by the firm during the year (to be denoted by INTRINP).
- **Capital:** the net value of fixed assets of the firm at the beginning of a year (to be denoted by FA).
- **Labour**: the total number of mandays worked during the year (to be denoted by MDW).
- **Age:** the difference between the current year and the firm's initial production year (to be denoted by AGE).

For each selected year only those units are retained for analysis for which information was available on all these input-output variables specified above. If some of the observations are absent, then either the firm is not participating in the production process or there is some reporting bias. Hence, that observation is dropped from the data set[5].

Table-1

Retained No of Firms

Year	Total No.	Retained No.	% of Retained Units
2000	2674	1,797	67.20
2002	3687	2,677	72.61
2004	4855	2,878	59.28
2006	4580	3,108	67.86
Total	15793	10460	66.23

Table-1 shows the number of firm finally retained to estimate the TE score for different years at all India level. On an average more than 30% of observations have to be discarded due to incompleteness in data file.

5 To calculate the technical efficiency score here the popular DEA package DEAP has been used.

Analysis of Technical Efficiency:

Table-2 reports the summary statistics of TE Scores over time. The mean value of TES never exceeded 35%, indicating a very low level of technical efficiency and, therefore, a significant scope for improvement even within the existing set-up. The Median value is always lower than mean suggesting a stronger concentration of firms at low level of efficiency. This claim is supported by both declining standard deviations and increasing skewness across years.

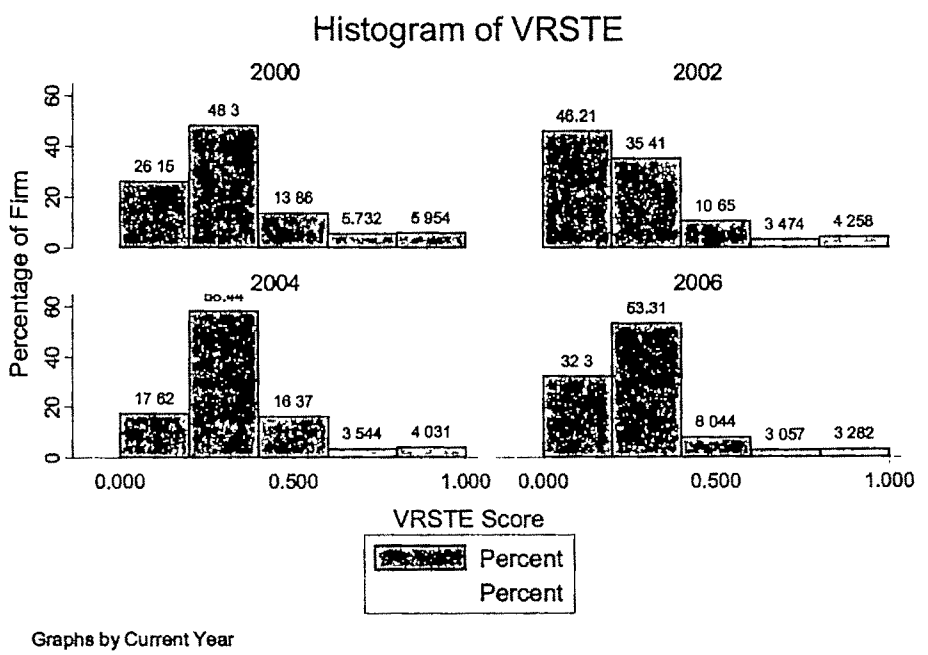
Table-2

Descriptive Statistics of VRSTE Score

Year	2000	2002	2004	2006
Mean	0.336	0.272	0.332	0.279
Median	0.272	0.217	0.280	0.227
SD	0.216	0.209	0.184	0.174
Skewness	1.529	1.696	1.805	2.348
Kurtosis	5.047	6.005	6.753	9.070
CV	0.642	0.770	0.554	0.623

Chart-2

All India Level Year-Wise Histogram of VRSTE



The Chart-2 indicates continuous fall in the percentage of the firms belonging to the highest level class boundary of VRSTE score. In 1999-2000 the 26.15% firm was at the bottom level class boundary of VRSTE score. It has gone up to 46.21% in the year 2001-2002 suggesting strong structural change of the industry. However, there was subsequent sign of recovery in terms of technical performance, though with high order of volatility. Table-3 reports a steady decline in the percentage of efficient firms (from 3.51% in 1999-2000 to 1.83% in 2005-06) where efficient firms enjoy technical efficiency score (TES) equals unity.

Table-3

Efficient and Inefficient Firm (Number and Percentage)

Year	Inefficient	Efficient	Total
2000	1,734	63	1,797
(%)	(96.49)	(3.51)	(100)
2002	2,609	68	2,677
(%)	(97.46)	(2.54)	(100)
2004	2,797	81	2,878
(%)	(97.19)	(2.81)	(100)
2006	3,051	57	3,108
(%)	(98.17)	(1.83)	(100)

Analysis of Slacks:

At this juncture it would be interesting to analyze the pattern of input and output slacks experienced by the inefficient firms. There is no significant slack in the use of materials or intermediate inputs(INTRINP) ; here the percentage is generally less than 1. Since the purchase of materials does not call for any pre-commitment, hence, this judicious use of raw materials is rather expected from the established firms. The slack in labor use (MDW) is distinctly higher than that in capital (FA) and one plausible explanation may be advanced in terms of the presence of unionized labor in registered manufacturing units. However, not too many firms are revealing inefficiency in terms of application of both FA and MDW. From the analysis of slack in AGE it becomes apparent that the older firms are generally more inefficient than the recently established ones, indicating the crucial importance of fast adoption of state-of-the-art technology in chemical sector. Finally, the percentage of inefficient firms without any input-slack is estimated and the corresponding percentage of manufacturing units with purely output slack is found to be more than 25% for all the time periods considered. These firms have selected the right technique of production but are inefficient due to choice of sub-optimal scale of operation.

Table-4

Percentage of Firms having Slacks in Input-Used /Output- Produced

Year	INTRINP	FA	MDW	AGE	FA+MDW	OUT
2000	0.5	17.03	20.98	46.41	6.90	28.32
2002	0.86	9.97	33.81	50.99	5.90	31.42
2004	0.97	16.09	43.26	44.65	3.93	25.19
2006	2.64	11.23	30.24	65.77	3.86	25.68

Analysis of Technology Gap:

India is a vast country with a number of states and union territories with their distinct social, economic, political and infrastructural features. Easy access to natural resources and other infrastructural facilities (which help in achieving lower cost per unit of output) is not evenly distributed all over the country. States differ widely in respect of stability of government formed by political parties, the nature of the overall political environment, and the level of militancy of labour unions, political and economic agenda of various governments and so on. Work culture of the people of some states is supposed to be more conducive to productive efficiency than what one finds in some other states (Das et al, 2009, pp. 415). All these factors are important determinants of the level of TE being attained by a firm located in a particular region. In fact, one may argue that even if the core production functions for the different regions were not different, these region-specific factors might cause their accessible production possibility sets to be different from one another and hence, from the grand production possibility set. It, therefore, makes sense to expect the production technology to differ across different regions of the country.

Here the states are grouped into three different categories on the basis of number of active firms present in the chemical production. If the number exceeds 250 for all year, we call it a MAJOR state, if it is between 100 and 250, we call it a MODERATE state and if the number is less than 100 the corresponding state has been identified as a MINOR state. According to this criterion Gujrat, Maharashtra and Tamil Nadu belong to Major group. Similarly, Andhra Pradesh and Uttar Pradesh belong to Moderate group. Remaining states belong to Minor group. Table-5 presents the name of the states belonging to different class.

Table-5

Classification of Major States

Class	Name of the State
Major	Gujrat (GUJ), Maharashtra (MAH), Tamil Nadu (TN)
Moderate	Andhra Pradesh (AP), Uttar Pradesh (UP)
Minor	Assam (ASM), Bihar (BIH), Haryana (HAR), Himachal Pradesh (HP), Jammu & Kashmir (JK), Karnataka (KAR), Kerala (KER), Madhya Pradesh (MP), Orissa (ORI), Punjab (PUN), Rajasthan (RAJ), West Bengal (WB)

Three category-specific group frontiers are used to obtain TE scores for the constituent firms for different production years under consideration.

Table-6

The Grand and Group Specific Average Technical Efficiency Score and their Differences

	Major			Minor			Moderate		
Year	Grand	Group	Gap	Grand	Group	Gap	Grand	Group	Gap
2000	0.336	0.394	0.058	0.350	0.435	0.085	0.289	0.609	0.320
2002	0.269	0.357	0.088	0.278	0.347	0.069	0.262	0.395	0.133
2004	0.341	0.460	0.119	0.315	0.349	0.034	0.339	0.468	0.129
2006	0.269	0.458	0.189	0.294	0.303	0.009	0.267	0.642	0.375

For all observations the year-specific grand frontier has already been obtained at the all-India level. Hence, combining these group frontiers and grand frontier, for each specific year, the technology gap has been assessed for each firm. Table 6 reports the summary statistics. It is obvious that the group TE score will always be greater than the grand TE score. The magnitude of the difference between grand and group TE basically indicates the region specific technology heterogeneity. For MAJOR states the difference between the mean values of Grand and Group is consistently increasing over time indicating a tendency towards increasing technological heterogeneity for these states. On the other hand for the MINOR states the opposite is observed where the gap between Grand and Group is diminishing over time indicating a tendency towards convergence[6].

6 These observations are consistent with the All-India scenario discussed earlier whereby a general tendency towards declining technical efficiency was noted. (The Group-wise and Year-wise histograms of Grand VRSTE and those of technology gap are presented in Appendix B)

The major states may be trying to retain their leadership position in this sector by adopting different types of technologies through collaborations and modernizations depending on their specific pattern of product-concentrations at higher levels of disaggregations. Table-7 identifies the major 4-digit level industries for different groups of states where most of the chemical manufacturing firms are concentrating[7]. The most important categories for the MAJOR states are NIC2411, 2423 and 2429 representing *manufacture of basic chemicals except fertilizer and nitrogen compounds*, *manufacture of pharmaceuticals, medicinal chemicals and botanical products* and *manufacture of other chemical products*, respectively that accounts for more than 75 % of total chemical production of these states taken together. In addition to these categories for the MODERATE and MINOR states two other categories are important, viz., *manufacturing of*

Table-7
Important 4-digit NIC Categories of Chemical Sector of India for Selected Years

State-Categories	NIC5	2000 (%)	2002 (%)	2004 (%)	2006 (%)
MAJOR	2411	1168 (23 44)	1238 (24.75)	894 (20.81)	1148 (23.87)
	2423	1174 (23.55)	1248 (24.96)	1034 (24.07)	1170 (24.31)
	2429	1691 (33.93)	1520 (30.39)	1319 (30.71)	1354 (28.13)
	Total (%)	**(80.88)**	**(80.10)**	**(75.59)**	**(76.31)**
MODERATE	2411	107 (7.76)	193 (14.64)	214 (16.28)	280 (21.45)
	2422	222 (15.96)	186 (14 08)	111 (8.48)	131 (10.10)
	2423	511 (36.72)	405 (30.59)	509 (38.61)	454 (34.80)
	2424	179 (12.86)	208 (15.78)	174 (13.25)	147 (11 32)
	2429	226 (16.28)	191 (14.49)	150 (11 44)	124 (9.53)
	Total (%)	**(89.58)**	**(89.58)**	**(88.06)**	**(77.20)**
MINOR	2411	269 (10.21)	292 (10.76)	180 (11.05)	482 (16 66)
	2422	275 (10.42)	233 (8.60)	136 (8.37)	280 (9 68)
	2423	912 (34.52)	859 (31.68)	609 (37.38)	862 (29.79)
	2424	375 (14.21)	414 (15.26)	238 (14.65)	505 (17.45)
	2429	523 (19.83)	551 (20.33)	262 (16.12)	404 (13.99)
	Total (%)	**(89.19)**	**(86.63)**	**(87.57)**	**(87.57)**

7 To arrive at an idea about the all-India scenario the unit level observations are adjusted with appropriate multiplers for observations presented in Tables 7 &8.

paints, varnishes, printing inks, etc. (NIC2422) and *manufacturing of soaps and detergents, polishing preparations, perfumes and toilet preparations* (NIC2424). In all these five categories explain more than 80% of total chemical production of the MODERATE and MINOR states.

Though ASI database reports 57 different categories of chemical producing units at the 5-digit level only 7 out of this 57 dominate the production front in India.

At the next stage of analysis we would concentrate on the major chemical products of the three MAJOR states at this 4-digit level and will further disaggregate them at the 5-digit level to isolate the exact producing units where the strength of the state lies. For example, because of its very rich tradition of textile production GUJ shows a high concentration of factories manufacturing dyes (NIC24114) and here the number of participating firms are steadily increasing over time. No such strong results are obtained for other constituent categories of NIC2411.

Table-8
Important 5-digit NIC Categories of Chemical Sector for Major States

Major States	NIC5	2000 (%)	2002 (%)	2004 (%)	2006 (%)
GUJ	24114	211 (11.15)	369 (19.53)	239 (15.57)	322 (18.10)
	24119	582 (30.76)	334 (17.67)	229 (14.93)	159 (8.95)
	24232	333 (17.60)	307 (16.27)	253 (16.49)	250 (14.07)
	Total (%)	**(59.51)**	**(53.47)**	**(46.99)**	**(41.12)**
MAH	24119	176 (12.31)	239 (15.48)	112 (7.94)	158 (9.87)
	24231	86 (6.00)	88 (5.71)	140 (9.92)	174 (10.87)
	24232	238 (16.63)	293 (18.98)	258 (18.27)	277 (17.30)
	24299	184 (12.88)	138 (8.99)	160 (11.35)	114 (7.14)
	Total (%)	**(47.82)**	**(49.16)**	**(47.48)**	**(45.18)**
TN	24291	681 (41.17)	584 (37.36)	525 (39.18)	503 (35 30)
	24292	331 (20.01)	291 (18.59)	260 (19.39)	324 (22.73)
	Total (%)	**(61.18)**	**(55.95)**	**(58.57)**	**(58.03)**

Table 8 presents the relative shares of important types of manufacturing units in Chemical sector in three major states at 5-digit level of disaggregation (accounting for nearly 50 to 60% of total chemical production). In case of basic organic chemicals (NIC24119) both GUJ and MAH are important players and in

both the states the relative importance of the product is declining over time. Stable presence of NIC24232, i.e., manufacturing of allopathic pharmaceutical preparation is experienced in both the states indicating their high level of involvement in pharmaceutical productions. In addition, MAH also produces fine chemicals like writing or drawing ink, etc. (NIC24299). Though GUJ and MAH more or less share the same concentration profile, the situation in TN is strikingly different. Here most of the chemical factories are concentrating in the manufacturing of matches (NIC24291) and manufacturing of explosives including firecrackers (NIC24292)[8].

The temporal pattern of average technology gap for all these manufacturing sectors have been analyzed further at the state-level and the result is reported in table 9.

Table-9
Changing Profile of Technology Gap of Chemical sector of Major States

Major States	NIC5	Statistics	2000 (%)	2002 (%)	2004 (%)	2006 (%)
GUJ	24114	Mean	0 070	0 106	0 119	0 167
		CV	0.830	0.885	0.578	0.660
	24119	Mean	0.062	0.112	0 119	0 123
		CV	1.046	0.669	0.644	0.974
	24232	Mean	0.053	0.100	0 093	0.137
		CV	1.431	0.578	0 789	0 708
MAH	24119	Mean	0.108	0.158	0 094	0.188
		CV	1 803	0.668	0 698	0 655
	24231	Mean	0.071	0.121	0.087	0 184
		CV	1 335	0.765	0.821	0 790
	24232	Mean	0 046	0.120	0.136	0.179
		CV	1.471	0.771	0.669	0 667
	24299	Mean	0.049	0.151	0 124	0.170
		CV	1.190	0.678	0.615	0.783
TN	24291	Mean	0.039	0.026	0 120	0 239
		CV	2.079	1.859	0.626	0.512
	24292	Mean	0.069	0.059	0.093	0 184
		CV	2.430	1.577	0.555	0.601

For all major states compared to 2000 in all major types of chemical production the technology gap has gone up drastically by 2006 indicating a tendency towards strong technology divergence. The gap between the technically efficient and inefficient units is sharply increasing suggesting the existence of transitory adjustment lags in face of a changing global economic order. It is only likely that the units which are more directly connected with the global market will have both incentive and compulsion to enhance technical efficiency through adoption of

8 It is interesting to note that NIC243 (manufacturing of manmade fibers) is not important in any of these major chemical producing states.

appropriate coping strategies. The others may eventually catch up being motivated by some trickle down effect, however, at present the gap is wide.

If at unit level (i.e., at the 5-digit level of disaggregation) it would be possible to study the change in the input-output structure and performance of the firm over time then the implicit suggestion made by the changing profile of technology gap could be tested explicitly. For that we would have to construct panel of observations which the present structure of ASI database does not permit.

V. CONCLUDING OBSERVATIONS:

This paper attempts to describe the scope, coverage, quality, advantage and limitation of ASI data in context of assessment of the performance of Indian Chemical Sector. Manufacturing sector plays a significant role for economic growth in India and chemical sector is one of the dominant sectors within the manufacturing sector. With respect to product and process diversity, the Indian chemical industry holds an important position. From the organizational point of view also there exists duality in terms of size (large, medium and small firms), in terms of employment (regular vis-à-vis contractual), capital use (types of financing) and production units (formal and informal). Moreover the industry is characterized in terms of vertical and horizontal linkages as well as pollution sensitivity. Since ASI provides database compatible with a few of these classifications in this paper an attempt has been made to measure the technical efficiency of this sector at all India level through Non-Parametric Data Envelopment Analysis (DEA). Due to availability of input and output related data in value terms for each registered factories this kind of analysis has become possible with ASI data. Here an attempt has been made to explain where the database is useful and where it lacks generality. Three important observations may be listed as follows:

(i) Given the available data at the factory level no longitudinal comparison is possible to check the efficiency profile of any particular class of firms over the phases of policy changes. The firm identification code, if generated, would be really helpful in carrying out panel data analysis;

(ii) Since no information about prices are available, only the status of technical efficiency can be assessed but not that of the allocative efficiency; Here the figures, if reported in terms of both physical volume/ number and value may help to proxy average price in some indirect way;

(iii) Finally, the abundance of missing observations at times limit the effective database to unusually small size that makes it inappropriate to carry out the overall efficiency analysis.

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Appendix: A

DIVISION [(NIC-3: 3) X (NIC-4: 9) X (NIC-5: 57)]: NIC-24: MANUFACTURE OF CHEMICALS AND CHEMICAL PRODUCTS (NIC-1998)			
241	**Manufacture of basic chemicals**		
	2411	**Manufacture of basic chemicals except fertilizers and nitrogen compounds.**	
		24111	Manufacture of industrial gases (includes manufacture of elemental gases, liquid or compressed air, acetylene refrigerant gases and mixed industrial gases etc.)
		24112	Manufacture of inorganic acids (nitric acid is included in sub-class 24121).
		24113	Manufacture of tanning or dying extracts, tannings and their derivatives and colouring matter (manufacture of indigo is included)
		24114	Manufacture of dyes (includes manufacture of such dyes and colouring matters which are for final use by household/industrial/institutional consumers, manufacture of special dyes used in laboratories e.g. to colour microscopic preparations is also included)
		24115	Manufacture of turpentine and resins of vegetable origin
		24116	Manufacture of organic acids (includes acetic acid): alcohols, phenols and phenol alcohols, methanol and higher alcohols.
		24117	Manufacture of basic inorganic chemicals n.e c.
		24118	Manufacture of industrial monocarboxilic fatty acids, acid oils from refining and industrial fatty alcohols ; Manufacture of glycerine.
		24119	Manufacture of basic organic chemicals n e.c.
	2412	**Manufacture of fertilizers and nitrogen compounds**	
		24121	Manufacture of nitric acid, ammonia, commercial ammonium chloride, nitrates of potassium and other basic chemicals of nitrogenous fertilizer industry
		24122	Manufacture of straight inorganic fertilizers
		24123	Manufacture of urea and other organic fertilizers
		24124	Manufacture of mixed, compound or complex fertilizers
		24129	Manufacture of others fertilizers n.e c (manufacture of pesticides are classified in class 2421)
	2413	**Manufacture of plastics in primary forms and of synthetic rubber.**	
		24131	Manufacture of synthetic rubber in primary forms
		24132	Manufacture of amino-resins, phenolic-resins and polyurethanes in primary forms
		24133	Manufacture of cellulose and its chemical derivatives in primary form
		24134	Manufacture of natural polymers and modified natural polymer in primary forms
		24139	Manufacture of other plastics in primary forms (including mixtures of synthetic rubber and natural rubber or rubber like gum e.g. balata, in primary forms)

242	**Manufacture of other chemical products**		
	2421	**Manufacture of pesticides and other agro chemical products**	
		24211	Manufacture of insecticides, fungicides and weedicides
		24219	Manufacture of other pesticides and agro chemical products
	2422	**Manufacture of paints, varnishes and similar coatings, printing ink and mastics**	
		24221	Manufacture of prepared pigments, prepared opacifiers and prepared colours, vitrifiable enamels and glazes engobes and similar preparations of a kind used in the ceramic, enamelling or glass industry
		24222	Manufacture of paints, varnishes, enamels or lacquers
		24223	Manufacture of printing ink (manufacture of writing or drawing ink is classified in sub-class 24299)
		24224	Manufacture of pigments and other colouring matter of a kind used in the manufacture of paints or by artists or other painters
		24229	Manufacture of mastics, caulking compounds or similar non-refractory filling or surfacing preparations; prepared other paints/ varnishes removers; organic composite solvents and thinners, and other related products n.e.c
	2423	**Manufacture of pharmaceuticals, medicinal chemicals and botanical products**	
		24231	Manufacture of chemical substances used in the manufacture of pharmaceuticals: antibiotics, endocrine products, basic vitamins, opium derivatives; sulpha drugs; serums and plasmas; salicylic acid, its salts and esters; glycosides and vegetable alkaloids; chemically pure sugar etc.
		24232	Manufacture of allopathic pharmaceutical preparations
		24233	Manufacture of 'ayurvedic' or 'unani' pharmaceutical preparation
		24234	Manufacture of homoeopathic or biochemic pharmaceutical preparations
		24235	Manufacture of veterinary preparations
		24236	Manufacture of surgical dressings, medicated wadding, fracture bandages, catgut and other prepared sutures
		24239	Manufacture of other pharmaceutical and botanical products n.e.c.
	2424	**Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations**	
		24241	Manufacture of soaps all types (includes medicated soap, household soaps, rosin, naphthenate soaps and industrial soaps)
		24242	Manufacture of waxes & polishes (includes manufacture of artificial waxes, prepared waxes; polishes and creams for footwear, furniture, floor, coachwork, glass or metals and scouring-pastes/powders and similar preparations)
		24243	Manufacture of organic surface-active agents (surfactants) and preparations based thereon, detergents, auxiliary washing preparations (for rinsing or bleaching cloths) and cleaning preparations (for floors/windows etc.)
		24244	Manufacture of perfumes and cologne de-eau

		24245	Manufacture of preparations for oral or dental hygiene (includes manufacture of toothpastes, toothpowder, mouthwash, oral, perfumes, dental fixative pastes and powders etc.)
		24246	Manufacture of cosmetics and toileteries (includes manufacture of pre-shave shaving or after shave preparations, personal deodorants and anti-respirants, perfumed bath salts and other bath preparations, beauty or make-up preparations and preparations for the care of the skin, other than medicaments; manicure and pedicure preparations etc)
		24247	Manufacture of hair oil, shampoo, hair dye etc. (includes manufacture of shampoos, hair sprays, hair fixers, hair oils, hair creams, hair dyes and bleaches and preparations for permanent waving or straightening of the hair etc.)
		24248	Manufacture of "Agarbatti" and other odoriferous preparations which operate by burning
		24249	Manufacture of other perfumes & toilet preparations n.e.c
	2429	**Manufacture of other chemical product n.e.c.**	
		24291	Manufacture of matches
		24292	Manufacture of explosive, ammunition and fire works
		24293	Manufacture of essential oils; modification by chemical processes (e.g. by oxidation, polymerization etc.) of oils and fats
		24294	Manufacture of photochemical products such as photographic plates, films, sensitized paper, other sensitized unexposed materials and chemical preparations for photographic use; manufacture of prepared unrecorded media for sound recording and similar recording of other phenomena (e.g. compact disks, diskettes and floppies)
		24295	Manufacture of gelatin and gelatin derivatives, glues of animal origin, prepared glues and other prepared adhesives including adhesives based on rubber or plastics
		24296	Manufacture of chemical elements and compounds doped for use in electronics
		24297	Manufacture of chemical products or preparations of a kind used in the textiles, paper, leather or like industries
		24298	Manufacture of processed salt
		24299	Manufacture of fine chemicals and other chemical products n.e.c. (including anti-knock preparations, anti-freeze preparations, liquids for hydraulic transmission, composite diagnostic or laboratory reagents, writing or drawing ink and other chemical products)
243	**2430**	**Manufacture of man-made fibers [This class includes manufacture of artificial or synthetic filament and non-filament fibers.]**	
		24301	Manufacture of artificial filament tow and staple fibers, not carded or combed.
		24302	Manufacture of synthetic filament tow and staple fibers, not carded or combed.
		24303	Manufacture of artificial filament yarn, whether or not textured, high tenacity, multiple or cabled
		24304	Manufacture of synthetic filament yarn, whether or not textured, high tenacity, multiple or cabled.
		24305	Manufacture of artificial non-filament or strip (e.g artificial straw).
		24306	Manufacture of synthetic non-filament or strip.

Appendix B:

Chart-B.1

State Group and Year-Wise Histogram of Grand VRSTE

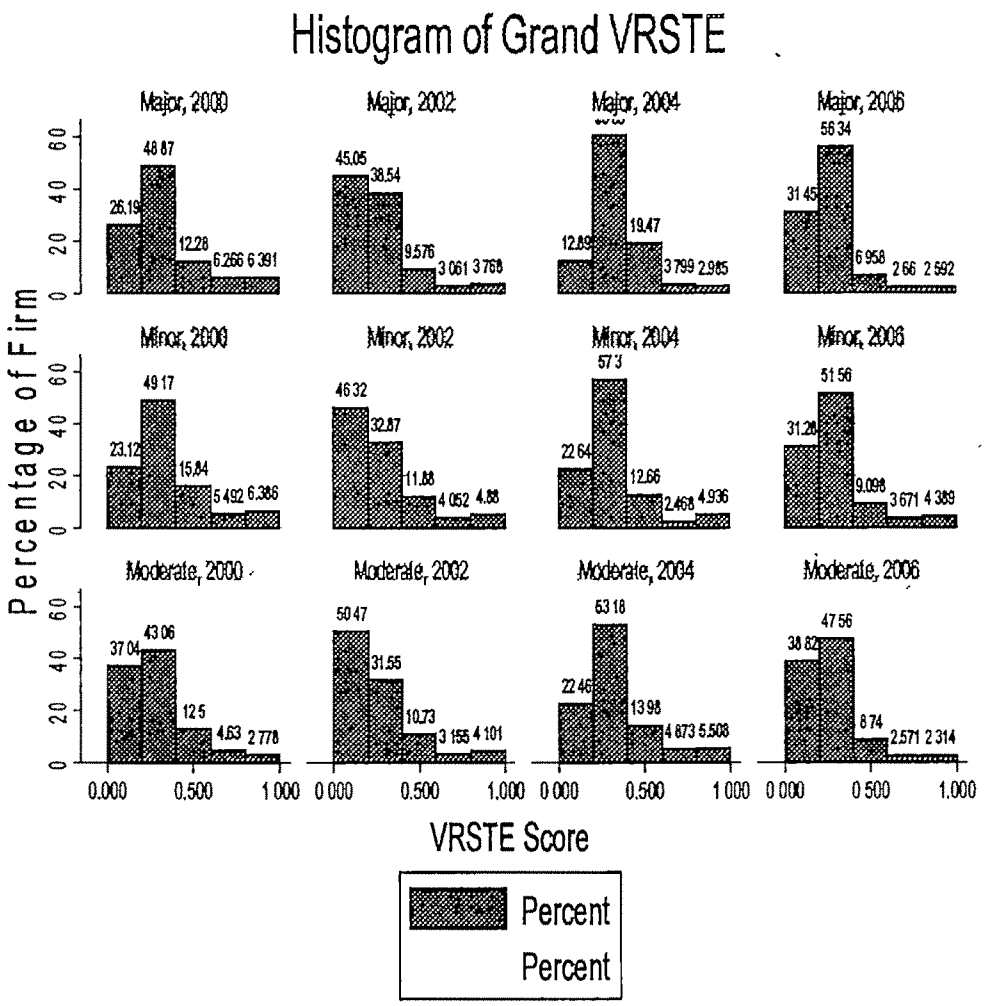


Chart-B.2
State Group and Year-Wise Histogram of Group VRSTE

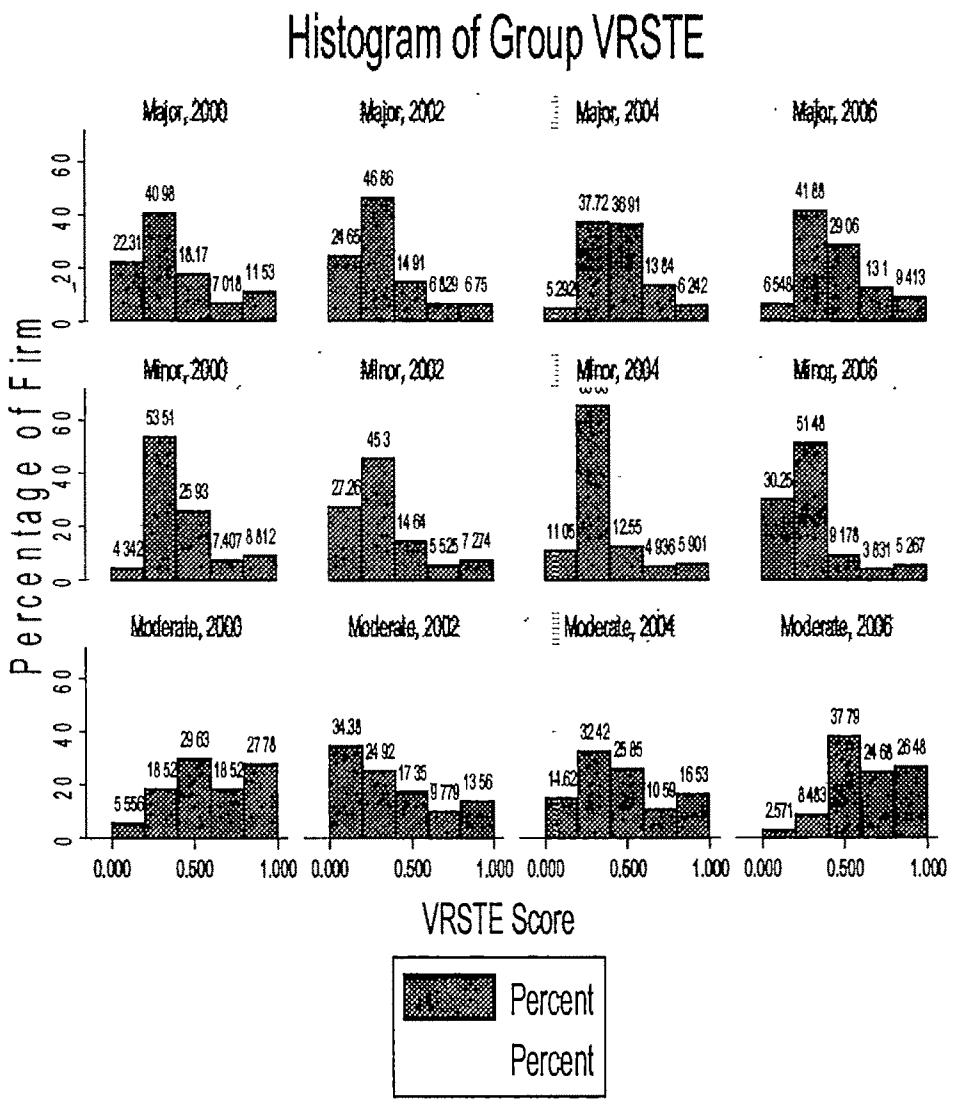
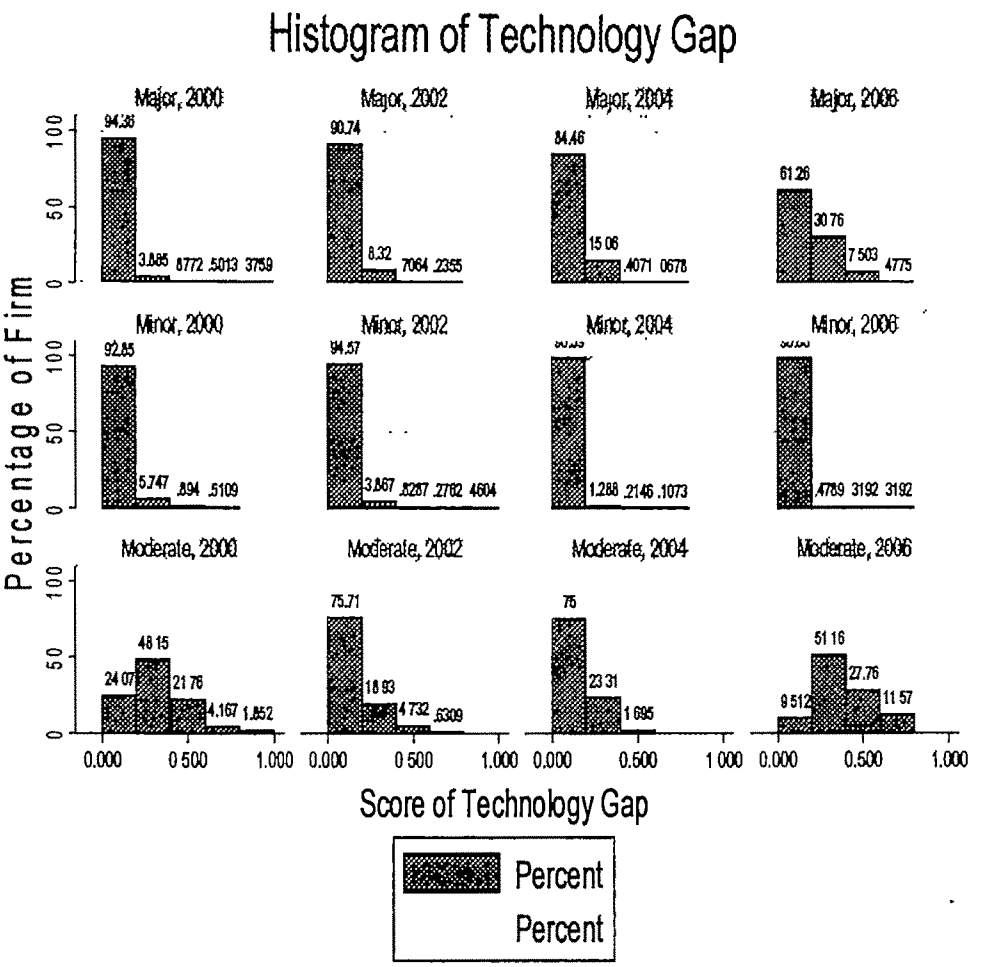


Chart-B.3
State Group and Year-Wise Histogram of Technology Gap Ratio



Arthaniti 9 (1-2), 60-70 / 2010

Book Review

Modern Growth Theory, Dipankar Dasgupta, 2010, Oxford University Press, New Delhi. Rs. 695.00.

Understanding growth has always been a major preoccupation of the best minds in economics. Starting with Adam Smith, generations of economists have been trying to understand the nuances of the process by which some countries emerge more prosperous than others. That intellectual query has been shaping the contour of theorization and empirical validation thereof of the process of growth in the economic literature. However, for an interregnum the prominent economists turned their eyes away from the problems of growth. They rather preferred to concentrate on the short-ends of the problems afflicting the economies in the post world-war period. Fortunately, that trend was not long-lived. The late eighties – specifically the famous speech of Robert E. Lucas – marks the resurgence of interest in the economics of growth. Several prominent economists have joined the fray to explore the variegated themes underlying the process of growth. All these themes, put together, constitute what is known as modern growth theory.

The present book under review provides a brilliant introduction to the modern theory of growth. The author himself a leading theorist has shown his expertise in presenting the results from the frontier of research in a very elegant style, suitable for readers with a good training in undergraduate economics.

The book deals with the recent developments in growth theory since the advent of Solow model. The author has opened the discussion with the original contribution of Solow. Cass-Koopman's optimization approach in dynamic general equilibrium framework has refined the Solow model so as to serve as the basis for launching the waves of subsequent developments in growth theory. In this context, it is important to take a look into the first welfare theorem which establishes the equivalence between the allocation by the social planner and the competitive equilibrium, *albeit*, under certain conditions. The author has devoted the first part of the book to the discussion of the above material. He has also taken the opportunity of introducing modern

mathematical technique of optimal control to the uninitiated readers. This technique is the key for getting access to the treasure house of modern growth theory. All these features contained in the first part of the book would provide the serious readers a sound foothold to counter the technical intricacies in the next part of the book.

The second part of the book consists of six chapters. They present post-Solow developments in growth theory. The discussion of new growth theory begins with Arrow's learning by doing approach. While discussing this approach the author has made a comparison of Arrow's approach with other models that have attempted to endogenise technological progress in Solow's model. This would help the readers to appreciate the impact of Arrow's contribution in the modern growth theory. The contribution of Romer, who distinguished between physical capital and human capital has been well emphasized. In Romer's model, the learning channel generates increasing social returns through human capital formation. The author has rightly pointed out the leniency observed in the practice of projecting the Harrod-Domar model as fixed coefficient technology model belittling the importance of razor's edge balanced growth path problem in Harrod's and excess capacity in Domar's model.

The chapter 5 of the book deals with the relation between provision of public goods and growth. Though the chapter has surveyed important contributions in this field an inclusion of the debate between private versus public provision of goods (particularly in case of education) would have enriched the discussion further.

The most interesting contribution of modern growth theory perhaps would be the recognition of the accumulation of human knowledge through research as a vital input to the growth. The author has summerised the models of Romer, Grossman and Helpman and Aghion and Howitt to capture their influence in the growth theory. These models share a common feature – use of human knowledge as a shield against the law of diminishing returns to physical capital accumulation from setting in. The existing knowledge has been recognized as a public good in Romer's model, which is available free of cost to all researchers, but the output of research, which is 'new knowledge', is *not* thanks to patent laws ensuring incentive compatibility for the research activity. The brand proliferation and quality ladders models of Grossman and Helpman establish the link between human knowledge, variety and growth. In

the brand proliferation model the introduction of variety in the final consumption basket has a scale effect on growth. The arrival of new qualities according to some stochastic laws to a fixed set of final goods coupled with a repetitive allocation of human capital ultimately produces a growth enhancing effect as has been the case with quality ladders model. Aghion and Howitt's model incorporates the Schumpeterian notion of creative destruction as the driving force behind the process of growth.

An upcoming area of research - the relation between growth and inequality has been discussed at the end. The seminal contributions of Alesina and Rodrik and Galor and Zeira have been succinctly summarized.

The present book by Dasgupta may be considered as a necessary inclusion in the bookshelves of the post-graduate students of economics. The book is comparable to any standard textbook in this field. Moreover, in price war, it will give thumbs down to its competitors.

Kumarjit Mandal

"Employment Role in Micro Enterprises in Himachal Pradesh – Theoretical and Qualitative Aspects" by Prof Vinod K Anand

The book "Employment Role in Micro Enterprises in Himachal Pradesh – Theoretical and Qualitative Aspects" written by Prof Vinod K Anand and published by the Indian Institute of Advanced Study, Shimla, is a rich mine of information on different aspects of micro and small enterprises the world over. It contains seven chapters apart from a very extensive bibliography and index.

The first chapter, i.e., Introduction, contains a vast literature on definitions and characteristics of small and micro units in particular and of the informal sector in general. It starts with the distinction between formal and informal sectors as given by ILO in a number of parameters like initial entry, nature of inputs used, type of ownership, scale of operation, techniques of production, skill

acquirements and nature of markets for the ultimate output. The characteristics of informal sector are discussed in terms of heterogeneity in economic activities, number of people employed and an inverse relation between firm size and informality of the sector. The importance of location of the unit lies in existence of moving units like vendors, hawkers, casual workers apart from permanent and temporary units. The life cycle of the enterprises, i.e., whether they are newcomers or non-growing or small growers or graduates- is also a perspective to distinguish between enterprises. Classification on the basis of services i.e., whether they are manufacturing, retailers, wholesalers or suppliers of services, or even overlapping, is also given.

There are classifications to be made on distinction between small scale and cottage industries as well. Small scale and village industries are distinguished from large scale industries again on the basis of investment (as revised from time to time by Fiscal Commission and different Committees) as also on the basis of activities and the number of people employed. The NSSO classification on the basis of the latter is also given (directory and non-directory small-scale enterprises).

In spite of so much information, the micro-level organization in the informal sector is not clearly defined anywhere. The author rightly concludes that informal sector is a fuzzy, blurred and indistinct concept and hence contemporary macroeconomic policies will not be able to address the issues constraining informal activities, e.g., the absence of labour unions and labour-protection laws, specially for the self-employed in the informal or non-formal sectors etc. make things different there.

One foreign part of literature concludes that informal sector suffers from the government attitude from being benign neglect to outright hostility.

The author describes informal sector as an entrepreneurial organization to create entrepreneurial opportunity which will create more jobs. Surveying literature from different parts of the world, he concludes that informal sector enterprises from all over the world specially in the developing world, share some characteristics in terms of number of people employed, the kind of products produced, the location, type of ownership (mostly single and female in many cases) type of employment (hired or apprenticeship, part-time or full-time etc), size and source of initial investment etc. He also concludes that in recent decades, small-scale activities in most of the developing countries are rising at a faster rate than the large-scale set-ups in a few countries. Since that small scale enterprises are extremely diverse and heterogeneous in all aspects, not only their contribution to the growth and development of a country varies, but also their problems and constraints are different. Thus the policy-makers and support agencies need to make different sets of policy packages to help them.

After presenting all kinds of possible definitions and characteristics of micro-units and informal sector, collected from the different parts of international

literature, which may create an apparent confusion regarding the different aspects of small units, the author presents a clear-cut picture or definition of micro enterprise that he works on in this study. The kind of micro-unit he studies is a unit in the informal (unincorporated/ unregulated) sector, producing and/or supplying goods (capital/consumer)/ services, excluding repairs but including agricultural processing and where the number of labourers /employees/ owners is 10 or less and at least one is in regular paid employment. In addition, the study is also restricted to units that are accommodated in permanent or semi-permanent structures, i.e., itinerant hawkers, vendors and casual workers are excluded.

The research methodology, as stated by the author is qualitative, based on administered questionnaire, interview and indicative feedback. No primary or secondary data is collected. Only 247 district-wise selected micro-enterprises out of approximately 29,000 units in the entire state of Himachal Pradesh are considered for the study. A few support agencies are interviewed. Some hypotheses are developed on the basis of existing literature on small units in the developing world, which are used to study the small units of Himachal Pradesh. The economic theory where required is applied and so are day-to-day realities faced by micro-enterprises. The larger system of political economy is considered as different tax codes, statutes are also important. The study recognizes its limitations as all kinds of micro-enterprises are not considered and it is based on a method of qualitative survey, that also on a very small scale.

In chapter 2 of the book, entitled Employment Generation : Policy Priority, the author presents the main features of the Economic Policy that the Government of India followed since independence. He also presents the main steps incorporated in the new Economic Policy of 1991. These are all known to any student of Economics even in the undergraduate level and were not required to be included in the book. The author, at the end of the chapter concludes that employment generation in the small scale sector is not only a policy priority but also the only way out to give a push to the economy. For this, all the obstacles inhibiting the existence and expansion of micro and small enterprises should be removed. The author recommends that labour laws should all be reformed to achieve more progress in the field of employment.

The 3rd chapter, Employment Potential of Micro Enterprises draws literature on the employment aspect of micro-units from international arena. The failure of formal sector to absorb all the unskilled labour in the developing countries makes the case for the informal sector strong. The lack of available data however makes the public authorities lose interest in the micro-units. The general impression of low cost and dispersed location in spite of having an inferior quality causes the products of micro-units to be popular among lower income people.

The available empirical study reveals that since the small firms tend to integrate vertically, they tend to increase their sales or value added to sales ratio. The employment is generated but according to the author's views, at a high cost.

So, in place of more production, it may lead to a high moral and ethical cost and rent-seeking and directly unproductive profit-seeking activities. The efficiency ratio measured in terms of labour-capital ratio termed as capital intensity indicating the capacity to absorb labour is high for small and micro firms, i.e., they have a higher capacity to generate employment. So, the governments in both developing and developed countries are showing interest in these units. Good governance is needed for the development of micro industry for the development of infrastructure, advancing of credit, providing training, advising for management, providing better tools and technology, improving infrastructure and marketing, devising and implementing support strategy, introducing reward system and encouraging strategic partnering.

According to the survey, in most of the developing countries, the quantitative contribution of the micro-units is that they contribute to the value-added growth, i.e., add to the over-time growth of GNP. They have their qualitative contribution also. The author finds a tremendous improvement in the participation rate of women in this sector in recent years in the developing world. The retail component in the contribution of micro-units is important for wealth creation. A positive interaction between farming and off-farm work, essentially in the micro and small sector adds to agricultural production according to one study.

Informal sector activity not only leads to an improvement in the standard of living in the households but also adds to the urban growth, specially in housing and employment. The author refers to a General Equilibrium model to find out that the informal sector increases its capital stock more rapidly than the formal sector.

Among the disadvantages of micro-units as mentioned in the book, the most important is their high degree of diversity and heterogeneity which makes the statement of a public policy difficult. Some potential advantages to be realized as mentioned in the book are scale, scope, experience and learning. Transaction cost is a disadvantage. Their advantages are behavioral in nature, relate essentially to human resources and disadvantages mainly lie in material resources.

The informal sector is stated to be fuzzy, but their built-in disadvantages can be overcome by initiating and implementing effective support strategy according to the author.

In the 1st section of the 4th chapter, i.e., Experience of other Countries, the author presents briefly the routine documents issued by the different government agencies and departments of Himachal Pradesh and of Government of India, regarding policy guidelines and incentives, concessions and facilities to industrial units in the state. He laments the unavailability of data and data base. Most of the information are found in 1999-2000-01. A lot of information is given in the book under study on different steps taken by the government of Himachal Pradesh like setting up of industrial areas and industrial estates in the state, launching of an ambitious programme called the "Deen Dayal Hathkarga Yojana" , a centrally

sponsored scheme and many other schemes to which both the state and the central government gives financial assistance. It identifies different kinds of small units according to demand, uses of resources, base of skill etc., and also their location in the state. It throws light on different aspects of employment of and the products produced by the small units.

The 2nd section occupies the major portion of this chapter and presents a review of literature and existing hypotheses (27 in all) and various aspects of the informal sector the world over. Five more hypotheses based on newly emerging studies are also there. All the hypotheses are validated against the experience gathered from various countries of Africa, Latin America and Asia, including different parts of India. The hypotheses relate to the aspects of employment creation and wage perspective of the informal sector, its forward and backward linkages, its characteristics as mentioned earlier, the capacity of the small and micro units to survive and grow despite government apathy and lack of demand, quality of heterogeneous products, low investment, high labour intensity, high output-capital ratio and higher labour-capital ratio, dispersed location, type of ownership, type of education received by the owners, their gender, whether migrant, the amount of working capital invested, investment of majority of total fixed and variable costs in certain fields, importance of wage labour and apprenticeship, long working hours, high rate of return to operational cost etc. Their constraints relate to infrastructure, accommodation, marketing , availability of basic inputs like labour, capital and raw materials, finance, risk aversion and lack of additional demand, government policies in terms of reforms, bureaucratic control and intervention etc.

The new hypotheses say that the number of micro and small enterprises is far larger than reported, they mostly operate in rural areas, the total cost does not increase as fast as the amount supplied and a positive correlation exists between the rates of growth of wage employment and the GDP and that the informal sector is not a source of economic dynamism.

The last section in this chapter deals with the political economy of the micro and small enterprises.

In the 5th chapter entitled Research Outcome and Existing Hypotheses, the 1st section presents a profile of Himachal Pradesh, its geography, history, its population, its districts etc. A list of raw materials, like wood, wool, bamboo, horse hair and horticultural produces used by the small and micro units of the state is also given. The 2nd section deals with the profile of the micro enterprise sector in the state. The findings of the research using the sample and the methodology as presented in chapter 1 are tested against the hypotheses given in the previous chapter. It also gives the limitations. The 1991 and 2001 census data, some other documents and interview are used for the survey. Considering registered, unregistered, wholesaling, manufacturing and servicing categories, it is found that unregistered units create much more employment than their registered counter-

parts. 68% in the 1991 census and nearly 50% in the 2001 census of the total working population are working in the micro units.

The study finds that 83% of the existing units in the Himachal Pradesh were established during the 1970-2000, most having a large size and around 86% of the employment being full-time. 85% of them are having single ownership, producing different types of products, mainly with local raw materials. The findings of the study are also validated against the hypotheses formed.

They were mostly established without state support having both backward and forward linkages, are labour-intensive with adaptive technologies but small-scale operation and skill acquired outside formal schooling system. The enterprises provide both efficient and profitable employment. The units have expanded with the support of the concerned authorities. Being labour-intensive and dispersed, they are acceptable to both indigenous entrepreneurs and also to final consumers. Though the micro-units have both high capital productivity and capital intensity, they have inferior quantity of products and lesser production costs than others. The hypotheses of heterogeneity of micro-units, their quantitative and qualitative growth are all true for Himachal Pradesh. The proportion of owners having formal education is high. The male-dominated micro-sector in Himachal Pradesh has negligible in-migration. The initial investment and working capital is modest and out of personal savings. The fixed and variable costs have their usual components, with the former accounting for 90% of the total costs in the micro sector. 80% of the micro units in the state show low capacity. The hypothesis that higher the population density in an area, higher is the number of wage-earners is also true for Himachali micro sector. The wage gap between micro and small units is found in this state also. The exact working hours could not be computed, but most probably would be little over 9 hours. The profitability in terms of rate of return, though not properly worked out, is not very high or impressive. The units are all inhibited by a number of exogenous and endogenous constraints.

Chapter 6 on Constraints to Enterprise Behaviour, discusses the many constraints faced by the micro and small enterprises in the world. The exogenous and endogenous constraints from demand and supply sides focus on three areas: product markets, access to inputs required to produce these products and finance. There are inter-regional, inter-country, inter-group variations in the intensity of these problems. An overview of constraints faced by many countries in the world, specially in Africa and in developed countries as well, and also in different parts of India identified in the study are presented.

Most of the units confess to facing the problems of infrastructure, like water, power, transport and also marketing, finance, risk aversion, lack of additional demand, lack of government support, government intervention, bureaucratic red tape, competition, lack of training etc. The problems of accommodation, availability of inputs like during rains and winter, higher rates steel sale depot in the state etc. and constraints arising from the on-going reform process are the other

difficulties. The government support also lacks excepting that the Khadi Village Industries Corporation (KVIC) provides all the required facilities to the concerned. Apart from these as mentioned in the questionnaire, the additional ones mentioned by the respondents are uncertain markets, pollution, indifference of public authorities, lack of innovation and lack of work culture on the part of the people.

The respondents, during the interview, have suggested a few improvements relating to infrastructure improvement, subsidy, specially on capital and machines, and finance policies, R & D, removal of government intervention, providing incentives for exports, training facilities, establishment of a special unit to look after the tax and excise rebates, improvement of banking facilities, generation of additional demand for the products of the micro units, better implementation of the existing government policies, locating the units near the markets, implementation of strict and deterrent policy to stop duplication and copyright violation, establishment of government steel sale depot in the state etc.

The respondents agreed to the fact that the sector faces many problems, like in areas of registration, tax regulations, financial assistance, minimum wages, restriction of working hours, safety and security in employment, poverty alleviation programmes, training programmes, industrial estates, small business support centres, accommodation, encouraging indigenous area-specific crafts, information provisions and the rate of contracts for purchase by the government depots.

The government policies appreciated relate to incentives like sales tax and electricity duty exemption, income tax holiday, transport subsidy etc. The awareness created at the grass-root level and the creation of an industrial culture are also appreciated.

The author is skeptical about the reform process. He says though the patent system poses no threat to the micro sector as the products are age-old and non-obvious, the government should be cautious and the labour surplus economy of ours should be protected at any cost from the onslaught of reforms as the small scale sector has a tremendous potential of employment.

Chapter 7 entitled Support Strategy suggests that support strategy should broadly focus on capacity building for infrastructure delivery, training and educational development, micro-loan financing, training and research, partnership and institutional linkage, loan finance support and science, engineering and technology.

Support Strategy for HP, as recommended by the author, should be divided into two parts: one containing proposals that would push the micro-units to the threshold level and the other containing proposals that would pull the units to that particular level. The push factors are related to removing the barriers to entry and specific training to be imparted to prepare the entrepreneurs to enter and reach the threshold level. It should be such that the entrepreneurs should be encouraged to

invest the resources provided to them. Specific training programme for the entrepreneurs having link to the ongoing reform process and effectively incorporating the gender dimension should be evolved. The environment should be such that the people in the micro and small sector should be able to upgrade and increase their work skill and income and also facilitate the state's economy with the other growing regions of the country and the world. Providing of external finance including character-based lending, easing administrative process of loan request and expanding the flow of credit to them through commercial banks should be encouraged. Though the leading Indian banks play an important role in this context, new programmes have to be devised and the concerned authorities have to be guided by the most successful schemes of other countries like the Grameen Bank of Bangladesh etc. A specific target group may be identified, and a relationship of trust between lender and borrower should grow with a flexibility in loan application. A reform of the present labour law is also required.

The pull factors are different from the push factors. The government should invite and encourage the suppliers to bid for raw materials. Separate welfare packages for the poorest of the poor in the areas of nutrition, health, education and shelter should be developed. The legal recognition in the informal sector activities in the state is an important input of the support strategy according to the author.

A comprehensive policy framework involving the government, the private sector, the NGOs, financial institutions, business organizations, Trade Unions and the academia and covering economic, non-economic, administrative and even legal aspects of the micro-enterprise should be evolved. Designing a transparent tax regime, facilitating trade, supporting infrastructure should be included in the policy. Capacity building in most areas of development is an important aspect of support strategy, so is focusing on R&D.

The proposed support strategy as the author says, should also include effective remedies and their implementation to eliminate/ reduce both the endogenous and exogenous constraints, a proper supervision of laws, governing heath, safety, sanitation etc. of business activities, to see that no sector suffers because of protection given to other sectors. Migration to larger cities should be checked and that towards smaller centres should be encouraged.

The author concludes by saying that the support strategy mentioned above are meant for only the micro-enterprise sector of the state of HP, and the initiative should be implemented in piecemeal fashion. The support strategy mentioned above may be considered for other states also so that the micro-enterprises may transform themselves from the informal sector and may eventually occupy rightful place in the formal sector.

The book under review, is, as stated earlier, is highly informative and very rich in literature survey. A lot of international work is presented with reference. Any student or researcher, willing to pursue study on informal sector, small and

micro enterprises will derive immense help from the book. The author uses a simple language and carries on a lucid discussion to prove his points with utmost sincerity.

However, the book's main fault lies in the repetition of information and arguments. The book would have got a trimmer looks with a clearer picture of the study emerging without the repetitive information. Some information given in the book looks redundant as these are found in any standard text book of economics. The book actually is heavier in information on the subject under study from other parts of the world than that of Himachal Pradesh. Compared to other works, very few pages are dedicated to the study on the micro sector of Himachal Pradesh.

On the whole, the book is a genuine effort on a study of micro and small units in the particular state of Himachal Pradesh.

Dr. Sudakshina Gupta

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- Tables should be numbered consecutively in the text in Arabic numerals and printed on separate pages.
- Illustrations. Supply each illustration on a separate sheet, with the lead author's name and the figure number, with the top of the figure indicated, on the reverse. Supply original photographs; photocopies or previously printed material will not be used. Line artwork must be high-quality laser output (not photocopies). Tints are not acceptable; lettering must be of a reasonable size that would still be clearly legible upon reduction, and consistent within each figure and set of figures. Supply artwork at the intended size for printing.
- Final version of the papers must be submitted on floppy diskette in MS Word 2000 / Word Perfect 6.0 along with two hard copies.
- Final proofs will also usually be sent to the author for checking. This stage is to be used only to correct errors that may have been introduced during the production process. Prompt return of the corrected proofs, preferably within a week of receipt, will minimize the risk of the paper being held over to a later issue.
- Each contributor will receive one complimentary copy of the journal issue in which his/her paper appears. Additional reprints and copies of the journal may be ordered against advance payments.